

SCIENTIFIC AMERICAN

Supplement

No. 526

Scientific American Supplement, Vol. XXI., No. 526.
Scientific American, established 1848.

NEW YORK, JANUARY 30, 1886.

Scientific American Supplement, \$5 a year.
Scientific American and Supplement, \$7 a year.

PRESERVATION OF BUILDING MATERIALS BY THE APPLICATION OF A PARAFFINE WAX COMPOUND, AS RECENTLY USED UPON THE EGYPTIAN OBELISK, CENTRAL PARK, N. Y.*

By R. M. CAFFALL.

IN discussing the subject of waterproofing and preserving building materials, it will be necessary first to consider the causes of decay in such materials, and how it may be prevented.

The most powerful natural agent that disintegrates stone and other similar building material is undoubtedly water, especially when it freezes after it has entered into the interstices of the stone, as it then exerts a force that is irresistible.

Mr. Dexter A. Hawkins has told me that he had seen in the New England States immense boulders of granite near the roadside which had been so powerfully acted upon by freezing water that it was the custom of those living there, when they required material for repairing roads, to back their wagons up to one of these apparently indestructible masses of rock, and by simply striking it with a pick, it would crumble into small pieces, which were then shoveled into the wagon, drawn away, and spread where required. He also mentioned having seen in the cañons of Colorado and elsewhere in the West immense banks of debris, one hundred feet or over in height, formed of matter forced off by frost from the face of the rock cliffs above.

The evidence that water is the most destructive agent can be seen on any building where the exposed stone remains the longest in a wet state, as, for instance, the base of the wall near the ground, the stoops, the stonework under balconies, porticoes, window sills, etc.

But there are also other causes of decay, the chief one, in my opinion, based on long and careful observation, being the white salts which are so often seen upon our best buildings, those of brick more particularly. They are especially ruinous to building materials, are most difficult to overcome, and hence deserve extended notice.

(1.) As to their origin.—

These salts exist naturally in the clay from which the bricks, terra cotta, etc., are made; also in the lime used for mortar or cement. It is a well-known fact that many of the salts that are present in clay are insoluble while the clay is in its raw or natural state, but that the action of fire renders them soluble. The same result also follows the admixture of lime with the clay. Hence, agriculturists apply lime to the clay soils to render them more fertile, because the salts are made soluble by the action of the lime, and the plants are then able to assimilate them.

(2.) As to their elements.—These salts consist of carbonates, sulphates, nitrates, and chlorides of sodium, potassium, calcium, magnesium, etc. Sometimes several of these salts are associated in one sample taken from a building, and in nearly every instance that has come to my notice, I have found a difference of constituents and proportions; so much depending upon the clay and how it is burned, and the character of the limestone used for the mortar or cement. Hence arise the apparently contradictory statements and opinions expressed by chemists and others as to what these salts are composed of, some claiming one thing and some another; and I have no doubt that each may have been correct in his analysis, though, perhaps, widely differing from the others. I have taken two samples from the same building, and found them dissimilar. I believe that every kind of brick, cement, and mortar contains soluble saline ingredients.

(3.) The causes of their appearance.—This is wholly due to moisture in the masonry. This dissolves the salts, forming a weak brine, which, upon coming to the surface, loses its water by evaporation, and leaves the salt to crystallize and form the objectionable efflorescence.

The presence of the moisture may be due to the water used in mixing the mortar or cement, or in wetting the bricks; or it may be absorbed from the rain falling against the walls. Hence the drier the walls are kept during the erection of a building (consistent with making the work good), the less chance will there be for the salts to show themselves; and if the walls can afterward be kept perfectly dry, the salts remain inert and do no harm, because water is the agent that renders them active and effective in their resolving powers. It may sometimes be seen which parts of a building were built in dry weather and which in wet, by the appearance of the mortar joints at different elevations, especially on old brick structures.

To attempt to wash the salts off only results in their

England, nearly 150 years old, still active and troublesome. In Philadelphia, on October 4, 1882, I noticed the peculiarly white appearance of a great number of the houses, and I asked if they had been whitewashed. I then learned that the whiteness was wholly due to an extraordinary quantity of these salts on the surface of the walls, caused by a three days' rainfall that had occurred a few days before, and had completely saturated the brickwork, which upon drying out had produced the efflorescence. It by no means follows that the brick, cement, and lime severally are not good because they contain these salts, however undesirable these salts may be; in fact, I have constantly observed them in the very best qualities of each.

(6.) Responsibility of the profession and trades.—

Architects and builders are often blamed and held amenable for discolorations on buildings, and most unjustly so, when they are no more responsible for dirt settling upon and staining the walls, or for the salts that appear thereon, than are the shoemakers for our shoes getting soiled when we walk in a muddy street, or glaziers for our windows getting dirty from rain and dust.

Water will penetrate an ordinary brick; it will dissolve the salts in the walls, it will bring the same to the surface and evaporate and leave the salts to crystallize. Dust will float in the air and settle on exposed surfaces, and, if rain can fall upon them, it will most assuredly penetrate and permanently stain them. These are natural causes and effects, and no one can be justly and reasonably blamed for such things happening.

About a year ago, I was requested to examine a large new building in this city; the front was of a light yellow brick. The owner was moving his goods into it. It had become, as usual, stained, and the owner was retaining a part of the money, refusing to pay either architect or builder because of these stains. After a careful examination, I told him that neither of them was responsible; that the front faced the north, had been very wet, vegetable germs had settled upon it and grown, and the rain had washed floating particles of dust into it; and that the architect and the builder ought to have their dues. I asked him if he had withheld payment from the glazier because his windows had become dirty. His reply was, "Well, I will take good care that you don't see those parties." I said, "You asked for my opinion on your building, and I have given you a true and honest one."

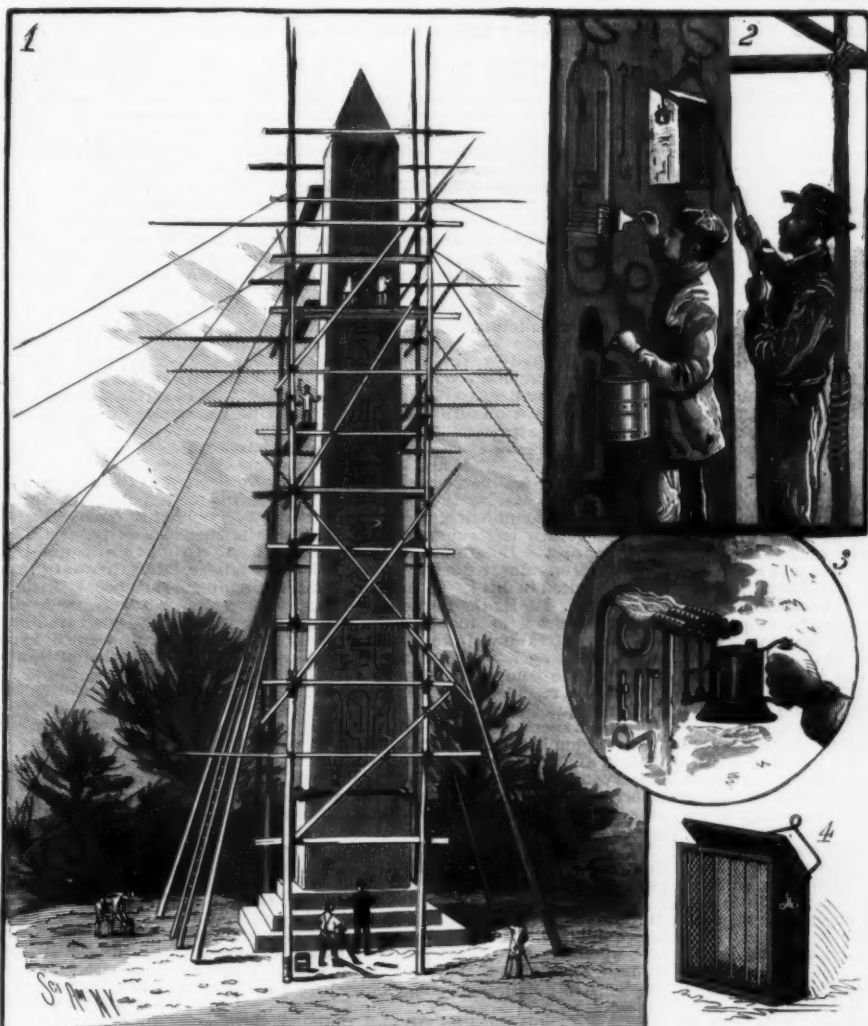
Here are for your inspection some pieces of brick taken a few days ago from a new building on 58th Street, near Sixth Avenue. You will see it had

been painted, and though the paint used was of good quality, as shown by its toughness, yet the destruction of the face of the brick and the forcing off of the coating of paint was wholly due to the caustic alkaline properties of these salts, which were brought to the surface and into contact with the paint by water. This effect can be seen, more or less, almost without an exception, on every brick house that had been painted with ordinary linseed oil paint. And if the paint thus perishes, so does linseed oil when applied alone, though the effect is not so readily seen. It is therefore neither durable nor effective. How often do we see the paint on a building peeling off the mortar joints and leaving them quite bare! This is due, as I have said, to the action of the lime salts in saponifying the oil.

Terra cotta shows these salts very much, in some buildings even more than the brickwork. This is noticeable on the new Produce Exchange Building. It is there caused, probably, by the liberal, though, perhaps, necessary backing of cement or mortar used to fill up the hollow spaces behind it, the salts of which come to the surface as before described.

Stone, especially in contact with brickwork, is damaged by the same cause. The water, no matter how it reaches the cement or mortar in a wall, will permeate through a stone, and bring with it these destructive salts, which quickly eat away the surface.

The late Mr. Francis D. Lee, a well-known architect of St. Louis, Mo., said he believed that the damage to



THE PRESERVATION OF THE OBELISK.

being dissolved and absorbed by the bricks, to reappear as the bricks dry. Rain does not wash them off, but into the surface of a building.

(4.) Other causes of production.—Salts of lime are produced by acids and alkalis contained in rain water, especially that falling in cities. Some twelve years ago an eminent English scientist estimated the quantity of sulphurous acid gas given off by the coal consumed in London at 300,000 tons annually. The carbonic acid gas from the same source must have been many times greater. These two gases have a great affinity for moisture, and are readily taken up by the rain which falls against and is absorbed by the brickwork, and are the most active agents in producing soluble salts of lime, and so causing it to dissolve, to appear afterward on the surface as previously described. Nitric acid, and also the alkali ammonia, act similarly. Their destructive effect on the mortar and cement joints is especially noticeable on the brickwork of the tops of chimneys that are in contact with the outflowing gases resulting from the fires beneath.

(5.) Effects of these salts on building materials.—The alkaline property of some of these salts is very destructive to brick, stone, cement, and mortar, completely disintegrating them, as may be seen by careful examination of the places where they show; nor can linseed oil, paints, or similar compositions withstand them, the oil being saponified by the alkali and rendered useless, so that the paint is destroyed and falls away. I have seen these salts in the walls of buildings in

* From a paper recently read before the N. Y. Academy of Sciences.

property, caused by the weather and these salts, was at least \$500,000 per annum in that city alone. If that was a correct estimate, who can compute the enormous loss to property owners in such a city as New York? The fact is, a certain amount of deterioration in house property is looked upon as a matter of course, as something inevitable, and therefore to be borne, like taxation, as philosophically as possible.

The question before us is, Can this disintegration be arrested or prevented? Can this natural law of decomposition be stayed? I believe it can, by shutting out or keeping off that destructive and ever active agent—water.

For the preservation of these building materials by waterproofing, the paraffine compound process is the most effective and lasting yet discovered. This statement is based, not on mere theory, but on many years of extensive application in varying climates, and on nearly every known kind of stone and building material.

I have had nearly twenty years of experience in this matter, sparing neither trouble nor expense to ascertain what is really the best thing to do. I have tried oils, varnishes, gums, rubber, and silica compounds, and made numerous experiments, but found no substance to have so many advantages and accomplish such perfect results as paraffine combined with creosote, applied with the aid of heat. It is imperishable, invisible, insoluble, impenetrable to water and gases, and it does not evaporate or waste away. It prevents the disintegration of stone, the weathering of brickwork, the crumbling of mortar-joints, the growth of moss and other destructive and unsightly vegetable organisms, the efflorescence of salts, and, in a word, it keeps buildings in a fresh, clean condition.

It renders the interior walls of hospitals, etc., impervious to the infectious emanations from the sick, thus keeping the wards healthy.

Although this may seem a large claim, yet every statement can be verified by accomplishment of successful work, extending over a long period and in many places.

The enemies of the exterior walls of our buildings are legion, but the strongest and, as I have shown, the ally of all is unquestionably water. The particular deduction from this established fact therefore is: Keep your house dry; it will last longer, look better, cost less to keep in repair, and be more comfortable and healthy for those who live in it. Each and all of these advantages are worthy of the fullest consideration of all owners of house property.

The proper time to treat a building is immediately after its erection, and before it becomes permanently stained and spoiled. But it is difficult to make owners or builders appreciate this. The following incident is one of many similar experiences. I saw in this city a very fine building in process of erection, white brick with brownstone trimmings. I knew it would quickly stain and be ruined. I brought this process to the attention of the owner; the front looked very fine indeed, though even at that time stains were beginning to show at the ends of the window-sills and other projections. The owner said the building was new, only just finished, and clean, and he did not see why it was necessary to do anything more to it. I replied, now was just the time to do it, and to keep it clean. He said he would wait a year or two to see if it stained, and if it did, then he would have something done to it. I need scarcely say that "then" will be too late, for there is no known process that will clean and restore a white or light-colored brick front to its original appearance. It is permanently ruined. "Prevention is better than cure," for in this case, if a decent-looking wall is desired, after it has stained, it must be coated with paint or color, and that forever prevents the brickwork from being seen again, except in spots, in a dilapidated condition, where the paint peels off.

The discoloration of the terra cotta of the new New York Cotton Exchange is rapidly taking place in spite of its coatings of linseed oil, and its light yellow bricks will ere long look like those of the building on the opposite corner, William and Beaver Streets, and those of the "Post" building, on Beaver Street and Exchange Place, which are stained beyond the possibility of restoration.

A very important consideration with an architect, in designing a good building, is color—the proper blending of shades. But of what use is it for him to be so careful in selecting brick and stone of certain tints, and to see that the builder and mason execute good, clean work, when in a few months after it is finished the whole of the beauty is completely marred by unsightly discolorations?

If it is worth while to spend time and money, and to take so much care in designing and erecting a substantial and handsome building, surely it is wise to spend a further comparatively small amount to permanently preserve the whole from the ruinous effects of the weather, which will surely follow exposure.

Let us now briefly consider in this connection a few of the stones used in New York buildings.

Brownstone is a popular stone, and deservedly so. There is a very substantial look about a brownstone house. The stone has a beautiful grain and sparkle, and does not, on account of its color, readily show the weather stains which are sure to occur in a city. But the chief objection to it is its liability to decay. It absorbs water freely, and then the frost quickly disintegrates it. If bedded on a dry, waterproof foundation, and protected from the action of water and frost, there is no reason why it should not remain sound and good for an indefinite time, and the above objection to its use would no longer exist.

The entrance to the Greenwood Cemetery, at Brooklyn, a fine brownstone structure, is badly decayed. It is said that many things have been tried to save it, linseed oil and sundry solutions, but all useless, none lasting over a year; and the beautifully carved work, erected at a great cost, seems doomed.

The *Carlisle* or *Scotch red sandstone*, though very beautiful in its color and grain, is probably the most absorbent of all the building stones used in this city. It certainly stains very quickly and badly, and cannot stand the weather. Any one can see this who will carefully examine any of it that has been exposed a year or two. Among the finest exterior work in New York is that on the front of the Hon. S. J. Tilden's house, in Gramercy Park, where the principal part of the exquisitely carved stone is this same red sandstone. The discoloration and decay are very marked. In

some places the costly carving is rapidly disappearing, a salt appears in many spots, which is said to be due to the stone having been wetted by sea-water. Its extreme porosity, more than that of some kind of brick, is against its being able, unprotected, to withstand the attacks of this very trying climate.

The blue *Wyoming stone*, from Pennsylvania, is a very hard, substantial stone, less absorbent and consequently less liable to decay than the former stones; but even this is damaged where in contact with brickwork, the salts of the lime and brickwork being carried into and through the stone and so corroding away its surface.

The light-colored Ohio and Nova Scotia *sandstones* are good, sound, hard stones, but owing to their delicate color they show the weather stains and become very unsightly, and are sometimes almost covered with a green vegetable growth. A large quantity of Dorchester stone was used in Central Park, especially on what is called the "Terrace" at the north end of the Mall. Here, a few years ago, an enormous amount of money was expended in executing a great deal of fine sculpture, but, alas! its beauty is rapidly fading away. Some portions are almost obliterated, and there is scarcely any that is not seriously damaged.

There are many buildings here constructed of *marble* of various kinds. It stains badly, and perishes more readily than is generally supposed. The old building of the Mutual Life Insurance Company on the corner of Broadway and Liberty Street was cleaned last summer. It was in a very bad state, and the stone near the top very much decayed. Some pieces of it here exhibited speak for themselves. I could dig into it in places a half an inch with my pocket knife. I have taken fragments of marble from old buildings in this city, and rubbed them into dust in my hand. You will observe that this piece of marble from the upper portion of the "Stewart" building, obtained when the building was being altered two years ago, has quite perished.

Limestone, oolites, etc., are not much used in New York, but where they have been, they show stains on their white surfaces, and abundant evidences of decay.

Granite is undoubtedly the strongest and most durable of building stones. But even it is not proof against the disintegrating forces. The *obelisk* is, unfortunately, an illustration.

I saw the obelisk for the first time about six months after its erection in Central Park. Being interested in the preservation of stone, I examined it as carefully as I could from a distance, and saw how rough the western and southern sides were, but, being unable to approach it closely, could form little idea of the actual condition of the surface.

On many subsequent occasions, I examined it closely, and after a time found small pieces of the granite lying around the base, which, to me, clearly proved that it was being affected by the severe climatic influences.

Professor Doremus accompanied me, about a year ago last September, to examine the obelisk. We gathered quite a quantity of it from around its base. He showed the pieces we had picked up to the late Commander Goringe, who could hardly believe they came from the monolith, and expressed the hope that some day it would be polished. Hence Dr. Doremus refrained from pressing the matter of its preservation with the park commission.

On his return last summer from Europe, the then President of the Board, Mr. J. D. Crimmins, wrote to Professor Doremus, requesting his opinion and advice, which resulted in his letter published last September.

The Hon. M. E. D. Borden was finally intrusted with the decision as to the proper treatment to be adopted. After consultation with Prof. Doremus, and a visit to the obelisk with him, Mr. Borden decided on the paraffine compound application. On September 23, 1885, we received a letter from the Park Commissioners, requesting us to treat the north side of the plinth as a specimen of our waterproofing process.

On September 25th, my son and I went to the obelisk, and commenced the work, when I discovered that I could remove quite large scales with my fingernails from the surface of the plinth, and also that there was a green vegetable growth behind each piece removed.

This was so serious that I thought it better to call the attention of the authorities to its condition before proceeding with the work.

It took my son and myself several hours to take off the decayed portions. We then applied the waterproofing compound. I watched very closely the effect of the heat upon the stone, as so much had been said against using it, and found that it stood the necessary temperature perfectly well, not being damaged in the slightest degree.

Prof. Doremus was present, and watched the operation and applied some of the melted compound himself, and thus saw how readily the warmed surface of the granite absorbed the melted compound.

This accords with Professor Doremus' experiment, the year before, with a large piece of the obelisk given to him by the late Commander Goringe, which he heated and dipped in melted paraffine wax, and found to absorb it, the heat not damaging the stone.

I found, much to my surprise, that the stone absorbed the compound *very freely*, much more so than stone generally. This showed that there were many and large interstices into which water could pass; which, if frozen while there, would inevitably force off, with its resistless power, the surface of the stone. This confirms the experiments made by Professor G. W. Wigner, in 1878, respecting this stone, and published in the *Analyst*, which showed that "the absorbent power of the unchanged stone was at the rate of 73 grains per square foot; the weathered surface showed an absorbent power six times as great."

Some time afterward, we received the order to proceed at once with the scaffolding, cleaning, repairing, and waterproofing of the whole surface of the obelisk and its plinth.

We commenced on October 27, 1885, and the scaffolding was completed, in spite of bad weather and other hindrances, on November 2. We then began the cleaning of the stone, and discovered what a deplorable condition it was in, far surpassing our worst fears. Some large pieces were so loose that they would scarcely bear the hand on them without falling away. Walking around the monolith on a plank, I put my hand against one of the hieroglyphics to steady myself, when it came off in my grasp. We found the greatest disintegration

to be on the west side, very bad on the south, not so much on the north, and the least on the east, though decomposition had already progressed to a serious extent even on this side in certain places. We removed about two and one-half barrels of pieces, weighing altogether seven hundred and eighty pounds. Some of the flakes were so much decayed that even with the greatest care they would crumble to pieces when being removed. In quite a number of places we found the flakes, though separated from the stone and sounding hollow when tapped, yet seemingly firm in position. These we allowed to remain, if they would stand the heat. One especially large piece, which measured sixteen by seventeen inches, is on the base of the western face of the apex, or "pyramidion," and extending several inches down the western side. I consulted Commissioner Borden about it, and he said: "Don't remove any unless you are obliged to do so." I heated the piece carefully, and saved it. To have removed it would have seriously disfigured the top of the obelisk. This plan was carried out all through the work, and there is a great deal of the surface which, though hollow, will now stand for a great number of years, which, had it been left unprotected, would soon have fallen away. When the work of cleaning had sufficiently advanced, we proceeded to apply the waterproofing compound. This was on November 6, and we continued the work until November 13, when all was finished. Some part of the time, the weather was very boisterous; one could scarcely stand on the scaffolding, the wind had such force, especially on November 9 and 10.

As before stated, 780 pounds of pieces of decayed granite were taken from the obelisk, which proves beyond question that the stone, though only exposed four and one-half years, could not withstand the destructive influences of this climate.

What I have recently accomplished clearly proves also that certain statements made in the public press are unreliable, viz., the calculation that "it would require 58,056 years to remove from the plinth a shell one centimeter in thickness, and weighing 631,652 grammes" (or 1,338 pounds avoirdupois), and that "the waste in a century would therefore be scarcely a perceptible amount," as well as the concluding summing up that "we need, therefore, be under no apprehension that the obelisk will seriously suffer from the effects of our climate."

Secondly, it proves that "the suggestions of certain foreigners, who had visited Central Park, and said that if the obelisk was not protected, the frosts and snows of our severe winters would soon make more of an impression upon the stone than the thousands of years under an Egyptian sun," were reasonable and well founded.

Thirdly, that "a hot compound could not be made to enter the stone, without the use of a greater heat than would be possible without injury to the stone," was a groundless fear, because the successful heating and applying of the hot melted paraffine compound to the surface has been actually done without causing any injury whatever to the stone. This is a fact, not an opinion or a theory, and it speaks for itself. But for these unfortunate expressions of opinions from high authorities, made through the public journals, doubtless the obelisk would have been treated years ago, and much of this valuable and interesting relic and record of the past, which has now been irretrievably lost to posterity, would have been saved.

It was feared by some persons, as I have just stated, that this waterproof compound could not be applied to the obelisk without serious risk of injury. The trial has been made and no damage at all has been done, for, by a careful method of application, acquired by many years of experience, it was safely accomplished, and I do not think that a single particle of solid, sound stone was displaced from the surface of the obelisk by the application of the heat employed to enable the stone to absorb the compound to an effective depth. There were many witnesses to the correctness of this statement, some of whom watched especially for it. There were even spaces that were hollow beneath that were successfully treated. In some few instances, where the pieces were very loose and had a green vegetable growth behind them, as soon as the stove had warmed the stone, the steam came out of the humble but audacious plant-life at the back of the loosened scale, and these pieces we removed.

I believe the compound penetrated to a depth of half an inch and deeper. The stone certainly absorbed it in considerable quantities, no less than 67½ pounds having been used. The surface treated—shaft and plinth—is about 220 square yards. An equal surface of brownstone would have taken from 40 to 50 pounds. The work was effectually accomplished, and nothing was spared to insure a satisfactory result.

We did most of the work when the wind was blowing a gale from the northwest, and one squall that passed left our top poles covered with ice, though below it was simply a cold rain.

DISCUSSION.

Mr. Caffall, in answer to inquiries, said that ordinarily one pound of the paraffine compound would cover two to three square yards of brick surface. The compound penetrates the stone only as far as the melting-heat penetrates. If some of the liquid remains upon the surface, it demonstrates that the pores of the brick or stone are completely filled to the depth reached. Then a reheating causes the absorption of this excess, and leaves the surface clear. By this method, the thickness of the saturated layer is under control. The melting-point of the compound is 140° F. It consists of paraffine, containing creosote dissolved in turpentine. The use of creosote prevents organic growth upon the surface. The compound, in its constituents and its proportions, is the result of many experiments and long experience.

Prof. R. Ogden Doremus called attention to the statement of Prof. Persifer Frazer concerning the rock of the obelisk, contained in the eighth chapter of Commander Goringe's work on "Egyptian Obelisks," and read as follows: "The first thing that strikes one is the freshness and soundness of the rock. No *maladie de granite* is observable, and this fact will answer the first and natural question as to why this rock was so much preferred by the Egyptians for monumental purposes." Again, on page 167 Prof. Frazer says: "The rock of the needle can, therefore, be regarded as unusually fresh and healthy, in spite of the honorable age which it possesses."

If we assume that this professional report was correct, said Dr. Doremus, how terrible the ravages of four American winters on this historic monolith and its plinth!

Commander Gorrings felt confident of the permanency of the obelisk, remarking, in a way to close all discussion, when Dr. Doremus broached the subject of some preservative treatment, that "it had lasted nearly four thousand years, and will probably last four thousand more." When a handful of small fragments picked up from the top of the plinth were shown the commander, he could hardly believe they came from the obelisk. He expressed the hope that some day it would be polished.

During the past summer, while in London, Prof. Doremus had an interview with Dr. Birch, the world-renowned Orientalist of the British Museum, and showed him the fragments from the obelisk. He was not surprised, and remarked: "You will next find that pieces will come off in flakes, or scale off." As a verification of the prediction, Prof. Doremus proposed sending, in his care, for the British Museum, a piece of the obelisk with hieroglyphic markings on it, which is now in his possession. The fragment or flake was twenty inches long, and from two to six inches broad, but so fragile that it broke in half while being removed.

Cleopatra's Needle was treated, in 1879, by Mr. Henry Browning, with a solution of gum dammar dissolved in benzine, to which a small amount of beeswax was added, and a very small quantity of corrosive sublimate. Prof. Wm. Crookes had expressed an opinion that the paraffine compound was unquestionably to be preferred as a waterproof coating for the obelisk; and inquiries regarding Mr. Caffall's treatment of public buildings with the paraffine compound elicited only favorable replies.

Prof. Doremus also referred to the permanent character of paraffine and its use for resisting the action of the most powerful acids and alkalis.

Mr. P. H. Dudley made the following remarks: I visited the obelisk during the time Mr. Caffall was treating it with paraffine, and noticed particularly the flaking and crumbling of portions of the exterior surfaces of the shaft, from forty feet above ground down to the plinth. Above this the staving was down.

I was surprised to find parts of the rock so porous and full of minute fractures on the exterior; and gently tapping the shaft with a hand chisel at once indicated the location of many loose flakes from one inch in area to eight or ten inches. Most of the fractures of the flakes seemed of recent origin, although under most of them was found a green vegetable growth of unicellular plants. However, beneath some pieces the accumulated black dirt shows the fractures to be of more remote origin.

Photographs of the obelisk, taken as soon as the shaft was erected here (see "Egyptian Obelisk," by Gorrings), show numerous pieces broken out of the edges of the shaft, while the lower corners, resting on the "crabs" and plinth, have scaled off, as nearly all stone does under great pressure. The photographs show also that at least one side of the plinth had flaked before erection here, and all sides of the lower part of the shaft. The hieroglyphics are nearly obliterated on one entire side of the shaft, and their distinctness gone on about two-thirds of another side.

Placing a fragment of the rock under the microscope, portions of it show decided disintegration, parts of the hornblende being broken down and dissolved, while some of the white feldspar is broken into such minute fragments that they exhibit the Brownian movement when placed in water. In the minute crevices can be seen the green cells of vegetable growth, and on either side of the crevice may sometimes be seen, with the microscope, the rosy hue indicating internal strains in the very minute fragments, a slight increase of which would complete the fracture; and it is possible that the growing cells may furnish the necessary strain.

The green cells belong to the lowest class of vegetation, and, containing chlorophyll, are hence not fungoid. One class of the cells is rod shaped, from two to six micro-millimeters in length by one and one-half to two in diameter, the sides being straight, with slightly convex ends. On some pieces of rock, these were mostly in single cells, though two and three were connected in a straight line, never branched. These cells were attached to small microscopic fragments in colonies of one to five hundred, apparently by a gelatinous substance, and not easily detached after a moment's immersion in water. These cells require a power of about five hundred to show the cell-wall and the internal spore (?). Up to the present time, I have not been able to find a similar described form.

In addition to the oblong form, another class of round cells, belonging to the genus *Protococcus*, was found on the most disintegrated fragments. Some were round; others were subdividing into twos, quite similar to the figures given in the Botanical Atlas of *Protococcus phurialis*. So far, I have not found subdivisions of cells into threes and fours, as is found in the *Protococcus viridis* (?), so abundant on the trees in the Central Park near the obelisk. Besides these cells, spores of many other forms of vegetable life were found in abundance.

Dr. N. L. Britton, from his own microscopical observations, confirmed Mr. Dudley's statements as to the nature of the vegetable growth.

President Newberry said that brownstone was, upon the whole, a poor building stone, and some preservative treatment was most desirable and necessary. To find a substitute would be a good thing, even on aesthetic grounds, as a relief from the monotony of color in our streets. Some varieties were of fair quality, as the Long Meadow stone. A specimen of the Belleville stone had yielded eleven per cent. of lime, a soluble constituent. New York had grown up like a mushroom; the buildings were comparatively new, yet were already showing much decay. The marble roof of the assay office shows well the result of weathering; about one-fourth of an inch of the more soluble material has been removed, while the siliceous and less soluble parts are left projecting. The building of the State Cabinet of Natural History, in Albany, only fifty years old, built of Westchester marble, looks as if about to crumble. Many buildings in New York, the Cathedral for example, are of the same stone. In the city, the disintegration of stonework goes on more rapidly because of the greater quantity of sulphur fumes and carbonic acid in the air. But even in the pure air of the country, the limestone and the marble of burial grounds

show the soluble effect of atmospheric gases and water. Siliceous rocks endure better, but no kind of rock can long withstand, in our climate, the combined attack of acidulated water as a physical and chemical agent.

The speaker had no doubt that the obelisk was in a bad condition when it arrived here. Other specimens of Egyptian granite which he had examined showed that after an exposure, even in the dry climate of Egypt, of two or three thousand years, the rock becomes shaky. The disintegration is interstitial, and is not very evident to the eye. A fresh or recently quarried specimen of good granite, like the Aberdeen, would not in many years show any such decay as the obelisk has suffered. In the flakes from the obelisk exhibited this evening, the feldspar crystals are broken and the hornblende is quite gone. Some preservative should have been applied as soon as the monolith was erected here.

The president further said that he had knowledge of other processes of preserving stone, and that he had most confidence in a process using paraffine. It was certainly more efficacious than the silica treatment. The name of the substance signified its chemical inertness. It is most unchangeable, yet manageable. It is simple, and easily renewed, and not expensive. Apparently it works no injury to the stone. If it did not deface the stone, there could be no reasonable objection to its use. By this process, even if frequent renewal was necessary, the obelisk ought to be preserved indefinitely.

It is a surprise to Americans to find the famous cathedrals and buildings of Europe so much decomposed and subjected to repair. This process would undoubtedly have preserved them in all their original beauty.

Mr. R. N. Perlee said that his house of brownstone had been treated by the paraffine compound process, greatly to his satisfaction. Now, instead of the steps, railing, etc., becoming permanently soiled and stained, every heavy rain washed the stone as clean as new. His neighbors and friends were pleased with the appearance of the house, and he regarded the process as a first-rate thing, and one that would be greatly beneficial to the city.

Mr. Caffall said that the expense of treating an ordinary twenty-five foot brownstone front, with a porch, would be two hundred dollars to three hundred dollars. He did not know how long stone would retain the paraffine compound, certainly for a great length of time. He had word from England that buildings treated sixteen and eighteen years ago, the earliest treated, showed no evidence of loss. Buildings in St. Louis treated in 1879 showed no change. A committee sent to St. Louis to examine the buildings treated by this process found no instance of failure or dissatisfaction. He could not effectually treat damp surfaces. The steam issuing from the stone or brick formed bubbles in the paraffine compound, and also kept the pores open, thus defeating the purpose of the process.

At Monroe, Louisiana, the rise of water by floods is so great that a large surface of the brick piers of the bridge over the Ouachita River is exposed to floods of rushing water, and to alternate conditions of wet and dry. Four years ago these piers were treated with the paraffine compound, and recently the engineers had written that the condition of the brick and the mortar joints was still satisfactory.

The speaker thought that even if the heat of the sun was sufficient to melt the compound, the effect would only be to drive the fluid deeper into the stone. The evaporating point is about 500 degrees Fahrenheit.

The president said he had known the temperature of rock to reach 150 degrees Fahrenheit in the sun; but if the paraffine were melted, it would be held in place by capillary force.

Dr. Doremus expressed himself as a zealous advocate of the treatment of the walls, floors, and ceilings of hospitals, to render them impervious to poisonous emanations from patients.

Dr. Agnew had stated to him that many years ago the north wing of the old New York Hospital (Broadway near Duane Street) had to be abandoned in consequence of the impregnation of its walls with malignant influences from the reception of large numbers of sailors and immigrants with "ship fever." Thorough ventilation was tried for several months, with no avail. The walls were then scraped—several of the workmen becoming ill, and three died. Even after replastering the walls, this north wing had to be abandoned.

The Lincoln County Hospital in England became saturated with pyemic and septicemic poisons. Ventilation, scraping, and replastering the walls were tried in vain. Finally the hospital was torn down and rebuilt.

A few years ago the surgical wards of Bellevue Hospital were in a similar condition. Pyemia would prove fatal to patients who had undergone but trivial surgical operations. This was remedied by elaborate processes of disinfection with chlorine, but it required frequent repetition. Other hospitals in the city have found it necessary to employ chlorine gas as a disinfectant. Even the New York Hospital has been obliged to purify one of its wards by the liberal generation of this gas.

Now, if walls, ceilings, and floors can be rendered impervious and non-absorbent, they could then be washed occasionally with dilute solutions of corrosive sublimate, and hospitals, schools, hotels, etc., and all apartments where the sick are confined, could be kept in a healthful condition.

Mr. Caffall stated that after experiments, the authorities of the Broadmoor Criminal Lunatic Asylum for Great Britain placed the buildings, which held at the time eight hundred patients, in his hands. During several years of work upon it, about 40,000 square yards of interior walls were treated. The late Mr. George Jarvis, who had charge of the buildings, said that this treatment had reduced the death rate among the inmates from the "Broadmoor fever" fifty per cent. Previous to the walls being waterproofed, it was customary, after the death of a patient from "Broadmoor fever," to remove from the room the plastering of the walls and ceilings, which, however, was not always efficacious.

THE butcher bird, a small spotted bird, resembling the common mocking bird, is the foe of the domestic canaries on the Pacific coast, and destroys numbers.

CORRESPONDENCE THROUGH PIGEONS.*

Organization of Pigeon Cotes.—The young pigeons designed for stocking a cote should be from 30 to 35 days old. Is younger than this, they would find it difficult to feed themselves, and, if older, they might get lost on going out for the first time. On being introduced, a number is marked upon one of the feathers of the right wing, and a corresponding number is entered upon a register provided for the purpose. In this same register is entered a description of the bird, and where it came from. At the end of 25 days a number corresponding to that of the nest in which it was hatched is stamped upon one of the feathers of each bird brought forth in the cote, this sufficing to show its origin. The two kinds of numbers are distinguished by their dimensions. The keepers likewise keep a record of the couplings.

Food.—Experience has shown that usually the best food to give, in order to preserve the vigor of the birds, should be chiefly composed of vetches and chick peas, from January to April, at the time they are being reared, and horse beans during voyages. Salt forms an indispensable adjunct in every season. On another hand, since it is necessary that the messengers shall get into the habit of feeding themselves during a long flight, they are carried to the fields in baskets, after being deprived of food (but not of water) for twenty-four hours. On the first occasion they return to the open cage and enter it, but, not being able to get out again, and getting very hungry, the next day's experiment usually succeeds, as the birds then go to seek food in the fields in the vicinity of the cote. The cost of feeding each bird per year is about a dollar or a dollar and a quarter, and that of taking care of it about a dollar and sixty or eighty cents.

Coupling.—Those pigeons that are called "summer birds" that is, hatched from February to July, finish their moulting toward the end of October, and have then passed through the different phases of training. They then begin to couple of their own accord, thus permitting the males to be distinguished from the females. The first hatch is not usually a success, and toward the end of December the two sexes are separated for some weeks, so that they can obtain rest, and afterward mate at will and give a better product.

Rearing and Training.—The young pigeons hatched in the cote, and the 35-day old ones that have been introduced, are first let loose in the cote, so they may become accustomed to fly around without going astray. At the end of a week they will have got used to going out and entering again regularly, and the cage may then be opened from early morning during the entire summer season. The subjects are afterward left to themselves for two or three months, so that they can exercise themselves in flying and gain strength. Then, when they have reached the age of three and a half to four months, the training is begun. The best season for this is from the beginning of May to the end of September. The normal training consists in carrying the birds successively to distances whose rate of progression varies as follows: The second distance is double that of the first, the third is the same as the first plus the second and third, and so on. So, supposing the first stage was six miles, the succeeding ones would be 12, 18, 30, 48, 78, 126, 204, 330, and 534 miles. The last-named distance is rarely reached. In practice 420 miles is considered a maximum for the needs of war.

It is necessary, moreover, between each dispatching to allow the birds time to rest and become attached to the cote again. For short distances, one or two days suffice; but for those beyond 60 miles, the birds are permitted to rest four, five, or even eight days. The various stages of progression given above apply only to two or three year old birds; the first year they are not allowed to go beyond 18 miles.

One of the birds of a couple should always be kept in the cote, as the training depends largely upon the pigeons' domestic instinct. It is likewise well to avoid dispatching birds in a wind contrary to the direction that they are to take, and in rainy, snowy, or foggy weather.

The condition of the atmosphere exerts a great influence upon the flight of pigeons—thick fogs interfering with their sight, snow preventing them from taking their bearing, adverse winds necessitating too great an expenditure of strength, and storms accompanied with thunder and lightning frightening them. It has also been observed that the presence of a sea or a water course or a piece of woods makes them hesitate in their gait, and this is attributed either to the greater quantity of electricity contained in the atmosphere over water and forests, or, as regards the latter, to the fear of birds of prey. In order to preserve pigeons against the attacks of these latter, we may, as Mr. Bion proposes, paint their body and tail feathers with an infusion of one ounce of chewing tobacco in a quart of urine heated to 50° C., the mixture being applied cold. With the same object in view, the Chinese attach a kind of Aeolian harp to the bird's tail. But the efficiency of this mode of preservation is not admitted by pigeon fanciers, who assert that it frightens the pigeon more than it does its enemies.

Velocity.—The speed attained by the best practiced subjects varies. At the time the service was established between Paris and Versailles, in 1873, for the transmission of the minutes of the National Assembly, it frequently took the birds but ten minutes to make the twelve miles that separated the two stations. This was equivalent to a speed of 6,560 feet per minute. An experiment performed in 1877, between Dover and London, a distance of 68 miles as the bird flies, furnished the same result. In May, 1875, Mr. Cassier dispatched ten carrier pigeons from Moulins to Paris, and seven of these effected the passage of 174 miles in three hours, say with a velocity of from 5,250 to 5,575 feet per minute. But such figures constitute maxima that it is impossible to obtain with the average pigeon. Even a speed of 4,100 feet is regarded as exceptional, and the speeds usually reached do not, on an average, exceed 3,300 feet per minute for distances below from 30 to 36 miles, in clear weather; and in foggy weather they may drop to 1,960 to 2,300 feet. Moreover, we must expect to find a certain number of young and even old pigeons straying out of their course, and coming in late, sometimes several days after they have been dispatched. Some even get completely lost, and never again find their cote.

Organization of a System of Correspondence.—This

* Continued from page 5330, SUPPLEMENT, No. 522.

must fulfill two conditions, viz., (1) the distances must not be too great, as otherwise the voyage would too greatly tire the carrier, and (2) the stations must be distant enough to allow the bird to make a large use of its faculty, and make up for the time that is infallibly lost in getting its bearing at the start or in manipulating the dispatches on its arrival. Aside, then, from strategic and topographic conditions, which may impose other figures, the distances are generally varied between 60 and 120 miles. In France, communications are secured on the one hand between various places on the frontier, and, on the other, between these places and Paris. Pigeons kept for war purposes are yearly submitted to maneuvers, and every couple is specially trained to evolve in the direction that it must take in time of war.

Manner of Fixing Dispatches.—There are various methods of doing this. The process most usually followed, especially in France, is the one devised in 1870 by Mr. G. Blaye. It consists in inclosing the dispatches in a goose quill, about two inches long and open at both ends. After selecting a strong tail feather, this tube is tied to it with thread. After this, the dispatch, written upon thin paper, is carefully folded, rolled into the form of a cigarette, with one end smaller than the other, introduced into the tube, and wedged therein with a piece of match sharpened to a point. On its arrival at the cote the bird is captured with a net, and the tube and its contents are removed.

Organization of Military Cotes among various European Powers.—The organization of carrier pigeon services for war purposes is more perfect in France than in any other country. There is a large cote at Mont Valerien and eight others at Marseilles, Perpignan, Verdun, Lille, Toul, and Belfort.

Russia has established large cotes in various places, especially at Moscow, Kiev, Warsaw, etc., and there is a regular post between St. Petersburg and Krasnoe-Selo.

In 1874, Germany established pigeon cotes at Metz and Strassburg for 600 birds, and at Cologne and Berlin for 200. Since then cotes for 200 birds have been established at Wurtzburg, Mayence, Posen, Kiel, Wilhelmshafen, Tonnig, and Dantzig, and one for 1,000 birds at Thorn.

Austria has but two principal stations, one at Cornorn and the other at Cracow. England and Belgium have also a pigeon post for war purposes. In Italy, Spain, and Portugal the subject has not yet received much attention.—*Le Genie Civil.*

MECHANICAL WATER COOLER.

WHENEVER the supply of water for condensation purposes for the steam engine is small, the temperature of the reservoir rises to such a degree as to very seriously impair the vacuum in the condenser; this, of course, happens most frequently in places where the manufacturing are crowded together, and where, in consequence, there is little room to make a large reservoir, or if there is room, the great cost of the land prevents the construction of such a reservoir. It will be readily acknowledged that it is of the utmost importance in the interests of economy to obtain as good a vacuum as possible, which can only be secured by keeping down the temperature of the injection water. Messrs. Boase and Miller have patented the water cooling apparatus shown in the illustration, and which is designed to minimize the evils referred to. This machine consists of an outer circular sieve, which can be made to revolve at a high velocity. There is an inner stationary vessel, which descends through the air into the reservoir beneath, like rain. The object is attained, then, by simply dividing up the bulk of water into fine drops, each of which is thus enabled to part with its heat to the atmosphere. The illustration is taken from a photograph of a machine erected at Messrs. S. Anderton & Son's, Eastbrook Mills, Bradford. The machine stands about 11



IMPROVED MECHANICAL WATER COOLER.

ft. above the water, and rests on a good foundation of stonework. The sieve is driven, by means of the shaft shown to the right, at a speed of 300 revolutions per minute, absorbing in this manner about 3 horse power. Trials extending over eight weeks both before and after the machine was put down show that the mean temperature in the reservoir originally was 107°4', which fell to 95°9' after the cooler was erected, showing a reduction in

temperature of 11°4'. The reservoir served for three engines, but was pierced with a great number of small holes, through which the water from the hot well discharged into the machine finds its way into the outer revolving vessel, and from thence it is thrown out through the numberless meshes of the sieve in a fine spray, and water from one was passed through the cooler. It is stated that the vacuum in the cylinders was improved all round 1 lb., representing a gain of 36 horse power. From this must be subtracted 3 horse power required to drive the cooler and 5 horse power required to lift the water from hot well from the level of reservoir to the top of the cooler, which leaves a net gain of 28 horse power, making a difference in the coal consumption of 44 cwt. per week. The coal being valued at 7s. per ton, we see that a saving of more than 15s. per week is effected, less, of course, the interest on the original outlay and the cost of repairs and attendance. The apparatus has been in use now at Messrs. Anderton's and other large mills for a considerable time, and the advantages derived from its adoption have been proved to be real. The makers are Duncan Bros., London.—*The Textile Manufacturer.*

HOW SOLID CAST IRON FLOATS ON MELTED IRON.

At the Inventions Exhibition, London, a question which has formed a never-ending source of discussion



among iron founders, that is, the reason of a piece of solid cast iron floating in a ladle of the molten metal, receives its solution by an apparatus shown by Mr. Thomas Wrightson, of Stockton-on-Tees. This was brought before the notice of the Iron and Steel Institute some years ago, but as many of our readers may not have seen it at that time, we give the annexed engraving of it. The apparatus consists of a tripod sufficiently large to stand over a ladle containing about half a ton of fluid cast iron. From this tripod there is suspended by a chain a brass cylinder driven by clockwork, and carrying on its periphery a piece of paper on which a diagram is produced by a pencil, which rises and falls in accordance with the indications of a spring balance to which it is attached. From the spring balance there depends a rod carrying at its lower extremity the ball, the specific gravity of which, as referred to molten iron, is to be tested, and when the operation is progressing the ball is suspended in a ladle of fluid metal. Before the trial commences, however, a zero line is drawn upon the cylinder to represent the point at which the solid iron is of the same specific gravity as the fluid. To obtain this there is attached to the rod of the balance, which ends in an eye, a piece of bar iron of exactly the same section as the stalk projecting from the ball, and of a length sufficient to reach to the surface of the bath. This draws down the balance, and if the cylinder be rotated a straight line is drawn. The ball is then attached, and the whole apparatus is lowered by the chain until the stalk is submerged to the determined amount, the cylinder being set in rotation by clockwork at the same instant. Now, it will be evident that if the cast iron be of less specific gravity than the fluid metal, and, therefore, have a tendency to float, the ball will carry a portion of the weight of the rod depending from the balance, and the pencil will stand above the zero line. But it has always been found* that the first tendency of the ball is to sink, no matter how carefully it is lowered into the ladle. It then begins to expand under the action of the heat, and in a short time it attains the same specific gravity as the bath. The expansion still continuing, it becomes buoyant and raises the pencil above the zero line, and finally it melts, leaving on the paper a diagram which is an exact record of the change it has passed through. At the moment when the expansion is at its highest point, the ball is so soft and plastic that it is possible to thrust a pointed rod of wrought iron through and through the mass, the consistency being similar to that of putty. The instrument shows that, when passing from the solid to the liquid state, the

* The experiments were made with Cleveland No. 4 foundry quality of iron.

density of the iron is at its maximum when cold, at its minimum in the plastic state, and that the density in the liquid state is between the two extremes, although much nearer the solid than the plastic density. The following table gives the result of four experiments:

EXPERIMENTS ON THE DENSITY OF PLASTIC CAST IRON.

No.	Diameter of Ball.	Weight, in-crease of Stalk Immersed.	Maximum Sinking Effect.		Maximum Floating Effect.	
			Weight.	Per-centage.	Weight.	Per-centage.
7	in.	oz.	oz.		oz.	
8	3	594	2	3.4	24	3.80
9	5	2524	14	0.6	8	3.17
10	3	59	14	2.12	46	7.60
11	4	1324	4	0.2	64	5

—Engineering.

HYDROCARBON FURNACES FOR DENTAL OPERATIONS.

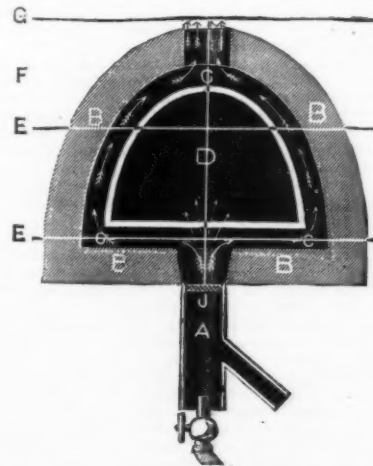
By Dr. C. H. LAND, Detroit, Mich.

To be able to fuse the body and enamel of which artificial teeth are composed, in an easy and convenient manner, is a thing the profession has studiously sought after, realizing that, when properly accomplished, the means to elevate prosthetic dentistry from an ordinary mechanical enterprise to one of true art would be at hand. The mere construction of a furnace after the usual modes has been simple enough, and the question of securing the necessary degree of heat was long ago accomplished. However, the ideal furnace demanded much more. It must possess not only the capacity of a coal or coke fire, but also accomplish the work in less time, and require but the minimum amount of exertion to operate it. Of the many attempts to produce such, nearly all have failed, owing to technicalities that were not well understood.

After many experiments, and their accompanying failures, it has been demonstrated that to heat an eight-inch muffle, three and one-half by two and one-half inches in diameter, to over 2,800° F. represents about a one man power, equivalent to the exertion of running the ordinary foot lathe or the No. 9 bellows, as manufactured by the Buffalo Dental Mfg. Co., which gives a working pressure of one and one-half pounds to the square inch, and corresponds exactly to the required amount of air pressure and volume necessary to heat an eight-inch muffle to 2,800° F. Therefore, to make a furnace larger would require too much power, and one smaller would not do for large pieces of work. In the production of a suitable furnace, the whole working apparatus must be as nearly air-tight as possible, and the supply of gas and air must be easily controlled and well balanced, with the least amount of friction in the passage through the pipes. These, with many minor details, form the basis of a practical gas furnace.

GASING THE BODY AND ENAMEL.

The most serious trouble with all gas furnaces has been the extreme liability of injuring the body and enamel by what has been commonly called "gasing." The accompanying illustration will make the philosophy of combustion more clear, and give the reasons why teeth are injured. A represents the burner; B B B, fire-brick lining; C C C, combustion chamber; D, interior of muffle. The arrows indicate the direction of the blast. The space in the combustion chamber between the lines, E E, is where carbon monoxide is formed, a gas containing one equivalent less of oxygen than carbon dioxide, simply an imperfect state of combustion. It is this gas that injures the body and enamel. By reference to the illustration, it will be seen that the little arrows are made to appear passing through the pores of the muffle; and as the direction of the blast from the burner, A, is directly against the bottom of the muffle, with a pressure of one pound to the square inch, a portion of the carbon monoxide is extremely liable to be forced through its pores, and will be taken up with the body during the first and second bisecting, here to remain until the enameling process, and as this takes a much higher degree of heat, it causes the gas to be eliminated, as shown in the numerous small bubbles on the surface. The space between the lines, E E, and within the combustion chamber, C C C, should be known as the first stage of combustion, where a certain portion of carbon monoxide is always present, and the space, F, between the lines, G and E, within the chamber, C, should be known as



the second stage, which is perfect combustion. In the first stage of combustion one equivalent of oxygen from the atmosphere unites with the hydrocarbon to form carbon monoxide; in the second stage, two, or perhaps three, unite to form carbon dioxide, or carbonic acid. Perfect combustion is always at the extreme point of the blow-pipe, as shown in the illustration.

The attempt, therefore, should be to place the muffle

as nearly as possible in the center of perfect combustion. As carbon monoxide is not consumed short of a temperature of over 2,200° F., the teeth should be kept in front of the muffle until it approaches a white heat. Starting from a cold muffle this will take about twelve minutes, and they should be gradually carried to the extreme end. At a high temperature there is very little danger of gasing, unless a greater quantity of gas is supplied than the furnace is capable of burning. Having constructed a furnace, and being familiar with many other details that provide a means to overcome all the apparent difficulties, the success of properly baking teeth seemed to be assured, until the muffle began to crack, which usually started in the second or third enameling heat. This led in such a quantity of the monoxide of carbon as to ruin the teeth. Here was a difficulty that was overcome by forcing a quantity of superheated air into the muffle, and backing all foul gases out. This proved to be a cure for gasing, but added an excess of oxygen, and it was found that this had a tendency to bleach the gum enamel to a lighter shade. The next step was to inject a pure atmosphere of nitrogen into the muffle, it being a neutral gas, not uniting radically with anything. This was eminently successful, and thoroughly demonstrated the fact that porcelain baked in an atmosphere of nitrogen was absolutely perfect, both in color and texture. It therefore gives me pleasure to be able to announce to the profession that the baking of all kinds of porcelain with any of the hydrocarbons has been brought within the range of every dental practitioner, so that with a little experience and knowledge of the above facts, artificial teeth can be baked, with unerring precision, in a very comfortable, cheap, and easy manner. By a simple attachment, each furnace produces its own nitrogen as fast as needed; and with recent improvements in the construction of muffles and the aid of a small motor, the author has been able to maintain a constant and uniform temperature above 2,800° F., by which a slab of sectional gum teeth was completed every seven minutes, at the will of the operator.

OLEFIANT GAS AND GASOLINE.

Olefiant gas, with which nearly all our cities and towns are supplied, is a compound of hydrogen and carbon. Its symbols are C_2H_4 , differing from gasoline only in its specific gravity, the composition of the latter being also C_2H_4 . The former will rise to the top of a building, while the latter will fall. The former is more penetrating, therefore, more liable to gas the teeth, and hence requires more care in handling. The quality varies in different localities, and sometimes, owing to the presence of ammonia, it may injure the teeth, or it may be too thin. When properly purified, it should be a rich hydrocarbon. The uncertainty of its qualities is frequently the cause of failure. To be successful with gas furnaces, it is absolutely necessary to have a pure and rich hydrocarbon. When the gas pressure is weak or the quality is poor, a gasoline generator may be attached to the pipe and the current allowed to pass through. This takes up a large percentage of the gasoline, and provides a very rich quality of gas. The eighty-seven per cent. is the best; seventy-four per cent. is too heavy to use without requiring heat to vaporize it. By applying to the manufacturers of the Combination Gas Machine Co., a supply can be had. When pure gasoline is used, it is necessary to have a generator so arranged that a portion of the air from the bellows will pass through it. This carries the vapor into the furnace, where it becomes mixed with the proper quantity of air, and will produce as good, if not better, results than any other hydrocarbon. All kinds of crucible and muffle work can be done equally well, also soldering and brazing with the blow-pipe. One gallon of gasoline costs fifteen to twenty cents; this will bake one set of teeth. Therefore, it will be seen that dentists living in localities where there is no gas will not be deprived of practically the same advantages as their city brethren. —Independent Practitioner.

REPORT OF THE COMMITTEE ON A UNIFORM SYSTEM FOR TESTS OF CEMENT.*

[Presented at the Annual Meeting, January 31, 1885.]

To the American Society of Civil Engineers:

Your Committee, appointed to devise a uniform system for tests of hydraulic cement, has the honor to submit this final report. Those portions of the preliminary report presented at the annual meeting held January 16, 1884, which are not embodied herein are superseded.

A uniform system of testing cement, in order to be practical, must be simple, rapid, and easy of application, and should, of course, be reasonably accurate. Between the very careful tests of the laboratory, which consume much time and involve considerable expense, and the rough and unsatisfactory trials often resorted to from necessity, there is a middle ground, which it has been the endeavor of the committee to occupy. The system proposed is by no means a perfect one—such has not yet been discovered—but it is hoped that it will be useful in eliminating many of the inaccuracies of the usual methods, and by making the system uniform, enable the experiments of the various members of the profession, in different parts of the country, and others interested in the subject of cement testing, to be satisfactorily compared.

TESTS OF CEMENT.

The testing of cement is not so simple a process as it is sometimes thought to be. No small degree of experience is necessary before one can manipulate the materials so as to obtain even approximately accurate results.

The first tests of inexperienced, though intelligent and careful, persons are usually very contradictory and inaccurate, and no amount of experience can eliminate the variations introduced by the personal equations of the most conscientious observers. Many things, apparently of minor importance, exert such a marked influence upon the results that it is only by the greatest care in every particular, aided by experience and intelligence, that trustworthy tests can be made.

The test for tensile strength on a sectional area of one square inch is recommended, because, all things

considered, it seems best for general use. In the small briquette there is less danger of air bubbles, the amount of material to be handled is smaller, and the machine for breaking may be lighter and less costly.

The tensile test, if properly made, is a good though not a perfect indication of the value of a cement. The time requisite for making this test, whether applied to either the natural* or the Portland cements, is considerable (at least seven days, if a reasonably reliable indication is to be obtained), and as work is usually carried on, is frequently impracticable. For this reason, short time tests are allowable in cases of necessity, though the most that can be done in such testing is to determine if the brand of cement is of its average quality. It is believed, however, that if a neat cement stands the one day tensile test, and the tests for checking and for fineness, its safety for use will be sufficiently indicated in the case of a brand of good reputation; for, it being proved to be of average quality, it is fair to suppose that its subsequent condition will be what former experiments, to which it owes its reputation, indicate that it should be. It cannot be said that a new and untried cement will by the same tests be proved to be satisfactory; only a series of tests for a considerable period, and with a full dose of sand, will show the full value of any cement; and it would be safer to use a trustworthy brand without applying any tests whatever, than to accept a new article which had been tested only as neat cement and for but one day.

The test for compressive strength is a very valuable one, in point of fact, but the appliances for crushing are usually somewhat cumbersome and expensive, so much so that it seems undesirable that both tests should be embodied in a uniform method proposed for general adoption. Where great interests are at stake, however, and large contracts for cement depend on the decision of an engineer as to quality, both tests should be used if the requisite appliances for making them are within reach. After the tensile strength has been obtained, the ends of the broken briquettes reduced to one-inch cubes by grinding and rubbing should be used to obtain the compressive strength.

The adhesive test being in a large measure variable and uncertain, and therefore untrustworthy, is not recommended.

FINENESS.

The strength of a cement depends greatly upon the fineness to which it is ground, especially when mixed with a large dose of sand. It is, therefore, recommended that the tests be made with cement that has passed through a No. 100 sieve (10,000 meshes to the square inch), made of No. 40 wire, Stubbs' wire gauge. The results thus obtained will indicate the grade which the cement can attain, under the condition that it is finely ground, but it does not show whether or not a given cement offered for sale shall be accepted and used. The determination of this question requires that the tests should also be applied to the cement as found in the market. Its quality may be so high that it will stand the tests even if very coarse and granular, and, on the other hand, it may be so low that no amount of pulverization can redeem it. In other words, fineness is no sure indication of the value of a cement, although all cements are improved by fine grinding. Cement of the better grades is now usually ground so fine that only from five to ten per cent. is rejected by a sieve of 2,500 meshes per square inch, and it has been made so fine that only from three to ten per cent. is rejected by a sieve of 32,000 meshes per square inch. The finer the cement, if otherwise good, the larger dose of sand it will take, and the greater its value.

CHECKING OR CRACKING.

The test for checking or cracking is an important one, and though simple, should never be omitted. It is as follows:

Make two cakes of neat cement two or three inches in diameter, about $\frac{1}{2}$ inch thick, with thin edges. Note the time in minutes that these cakes, when mixed with water to the consistency of a stiff plastic mortar, take to set hard enough to stand the wire test recommended by Gen. Gillmore, $\frac{1}{4}$ inch diameter wire loaded with $\frac{1}{2}$ lb. of a pound, and $\frac{1}{4}$ inch loaded with one pound. One of these cakes, when hard enough, should be put in water and examined from day to day to see if it becomes contorted, or if cracks show themselves at the edges, such contortions or cracks indicating that the cement is unfit for use at that time. In some cases the tendency to crack, if caused by the presence of too much unslaked lime, will disappear with age. The remaining cake should be kept in the air and its color observed, which for a good cement should be uniform; the Portland cements being of a bluish gray throughout, yellowish blotches indicating a poor quality, and the natural cements being light or dark, according to the character of the rock of which they are made. The color of the cements when left in the air indicates the quality much better than when they are put in water.

TESTS RECOMMENDED.

It is recommended that tests for hydraulic cement be confined to methods for determining fineness, liability to checking or cracking, and tensile strength; and for the latter, for tests of seven days and upward, that a mixture of one part of cement to one part of sand for natural cements, and three parts of sand for Portland cements, be used, in addition to trials of the neat cement. The quantities used in the mixture should be determined by weight.

The tests should be applied to the cements as offered for sale. If satisfactory results are obtained with a full dose of sand, the trials need go no further. If not, the coarser particles should first be excluded by using a No. 100 sieve, in order to determine approximately the grade the cement would take if ground fine, for fineness is always attainable, while inherent merit may not be.

Note.—Your committee thinks it useful to insert here a table showing the average minimum and maximum tensile strength per square inch which some good cements have attained when tested under the conditions specified elsewhere in this report. Within the limits given in the following table, the value of a cement varies closely with the tensile strength when tested with the full dose of sand:

American natural cement, neat:
One day; one hour or until set in air, the rest of the

twenty-four hours in water, from forty pounds to eighty pounds.

One week; one day in air, six days in water, from sixty pounds to 100 pounds.

One month (twenty-eight days); one day in air, twenty-seven days in water, from 100 pounds to 150 pounds.

One year; one day in air, the remainder in water, from 300 pounds to 400 pounds.

American and foreign Portland cements, neat:

One day; one hour, or until set in air, the rest of the twenty-four hours in water, from 100 pounds to 140 pounds.

One week; one day in air, six days in water, from 250 pounds to 550 pounds.

One month (twenty-eight days); one day in air, twenty-seven days in water, from 350 pounds to 700 pounds.

One year; one day in air, the remainder in water, from 450 pounds to 800 pounds.

American natural cement, one part of cement to one part of sand:

One week; one day in air, six days in water, from thirty to fifty pounds.

One month (twenty-eight days); one day in air, twenty-seven days in water, from fifty pounds to eighty pounds.

One year; one day in air, the remainder in water, from 200 pounds to 300 pounds.

American and foreign Portland cements, one part of cement to three parts of sand:

One week; one day in air, six days in water, from eighty pounds to 125 pounds.

One month (twenty-eight days); one day in air, twenty-seven days in water, from 100 pounds to 200 pounds.

One year; one day in air, the remainder in water, from 200 pounds to 350 pounds.

Standards of minimum fineness and tensile strength for Portland cement, as given below, have been adopted in some foreign countries.

In Germany, by Berlin Society of Architects, Society of Manufacturers of Bricks, Lime, and Cement, Society of Contractors, and Society of German Cement Makers.

Standard of 1877.—Fineness, not more than 25 per cent. to be left on sieve of 5,800 meshes per square inch.

Tensile strength, one part cement, three parts sand, one day in air, twenty-seven days in water, 113.78 pounds per square inch.

Standard of 1878.—Fineness, not more than 20 per cent. to be left on sieve, as above.

Tensile strength, same mixture and time as above, 142.23 pounds per square inch.

In Austria, by Austrian Association of Engineers and Architects.

Standard of 1878.—Fineness, same as German of 1878. Tensile strength, same mixture as above, seven days, one day in air, six days in water, 113.78 pounds per square inch.

Twenty-eight days, one day in air, twenty-seven days in water, 170.68 pounds per square inch.

In Austria a standard for the minimum fineness and tensile strength of Roman cement was established and generally accepted, as follows:

Standard of 1878.—Fineness, same as Portland.

Tensile strength (one part of cement, three parts of sand) for:

Quick setting cement (taking fifteen minutes or less to set):

Seven days, one day in air, six days in water, twenty-three pounds per square inch.

Twenty-eight days, one day in air, twenty-seven days in water, 56.9 pounds per square inch.

Slow setting cement (taking more than fifteen minutes to set):

Seven days, one day in air, six days in water, 42.6 pounds per square inch.

Twenty-eight days, one day in air, twenty-seven days in water, 85.3 pounds per square inch.

The Roman cements correspond to those classified in this report under the head of natural cements.

Standards have been adopted also by Sweden and Russia.

MIXING, ETC.

The proportions of cement, sand, and water should be carefully determined by weight, the sand and cement mixed dry, and all the water added at once. The mixing must be rapid and thorough, and the mortar, which should be stiff and plastic, should be firmly pressed into the moulds with the trowel, without ramming, and struck off level; the moulds in each instance, while being charged and manipulated, to be laid directly on glass, slate, or some other non-absorbent material. The moulding must be completed before incipient setting begins. As soon as the briquettes are hard enough to bear it, they should be taken from the moulds and be kept covered with a damp cloth until they are immersed. For the sake of uniformity, the briquettes, both of neat cement and those containing sand, should be immersed in water at the end of twenty-four hours, except in the case of one day tests.

Ordinary, fresh, clean water, having a temperature between sixty and seventy degrees Fahrenheit, should be used for the water of mixture and immersion of samples.

The proportion of water required varies with the fineness, age, or other conditions of the cement, and the temperature of the air, but is approximately as follows:

For briquettes of neat cement, Portland, about 25 per cent.; natural, about 30 per cent.

For briquettes of one part cement, one part sand, about 15 per cent. of total weight of sand and cement.

For briquettes of one part cement, three parts sand, about 12 per cent. of total weight of sand and cement.

The object is to produce the plasticity of rather stiff plasterer's mortar.

An average of five briquettes may be made for each test, only those breaking at the smallest section to be taken. The briquettes should always be put in the testing machine and broken immediately after being taken out of the water, and the temperature of the briquettes and of the testing room should be constant between sixty and seventy degrees Fahrenheit.

The stress should be applied to each briquette at a uniform rate of about 400 pounds per minute, starting each time at 0. With a weak mixture, one-half the speed is recommended.

* From the Transactions of the American Society of Civil Engineers, November, 1885.

* Where the word "natural" is used in this connection, it is to be understood as being applied to the lightly burned natural American or foreign cements in contradistinction to the more heavily burned Portland cement, either natural or artificial.

WEIGHT.

The relation of the weight of cement to its tensile strength is an uncertain one. In practical work, if used alone, it is of little value as a test, while in connection with the other tests recommended it is unnecessary, except when the relative bulk of equal weights of cement is desired.

We recommend that the cubic foot be substituted for the bushel as the standard unit, whenever it is thought best to use this test.

SETTING.

The rapidity with which a cement acts or loses its plasticity furnishes no indication of its ultimate strength. It simply shows its initial hydraulic activity.

For purposes of nomenclature, the various cements may be divided arbitrarily into two classes, namely, quick-setting, or those that set in less than one-half an hour; and slow-setting, or those requiring one-half an hour or more to set. The cement must be adapted to the work required, as no one cement is equally good for all purposes. In submarine work a quick-setting cement is often imperatively demanded, and no other will answer, while for work above the water-line less hydraulic activity will usually be preferred. Each individual case demands special treatment. The slow-setting natural cements should not become warm while setting, but the quick-setting ones may, to a moderate extent, within the degree producing cracks. Cracks in Portland cement indicate too much carbonate of lime, and in the Vicat cements too much lime in the original mixture.

SAMPLING.

There is no uniformity of practice among engineers as to the sampling of the cement to be tested, some testing every tenth barrel, others every fifth, and others still every barrel delivered. Usually, where cement has a good reputation, and is used in large masses, such as concrete in heavy foundations, or in the backing or hearting of thick walls, the testing of every fifth barrel seems to be sufficient; but in very important work, where the strength of each barrel may in a great measure determine the strength of that portion of the work where it is used, or in the thin walls of sewers, etc., etc., every barrel should be tested, one briquette being made from it.

In selecting cement for experimental purposes, take the samples from the interior of the original packages, at sufficient depth to insure a fair exponent of the quality, and store the same in tightly closed receptacles impervious to light or dampness until required for manipulation, when each sample of cement should be so thoroughly mixed, by sifting or otherwise, that it shall be uniform in character throughout its mass.

SIEVES.

For ascertaining the fineness of cement, it will be convenient to use three sieves, viz.:

No. 50 (2,500 meshes to the square inch), wire to be of No. 35 Stubs' wire gauge.

No. 74 (5,476 meshes to the square inch), wire to be of No. 37 Stubs' wire gauge.

No. 100 (10,000 meshes to the square inch), wire to be of No. 40 Stubs' wire gauge.

The object is to determine by weight the percentage of each sample that is rejected by these sieves, with a view not only of furnishing the means of comparison between tests made of different cements by different observers, but indicating to the manufacturer the capacity of his cement for improvement in a direction always and easily within his reach. As already suggested in another connection, the tests for tensile strength should be applied to the cement as offered in the market, as well as to that portion of it which passes the No. 100 sieve.

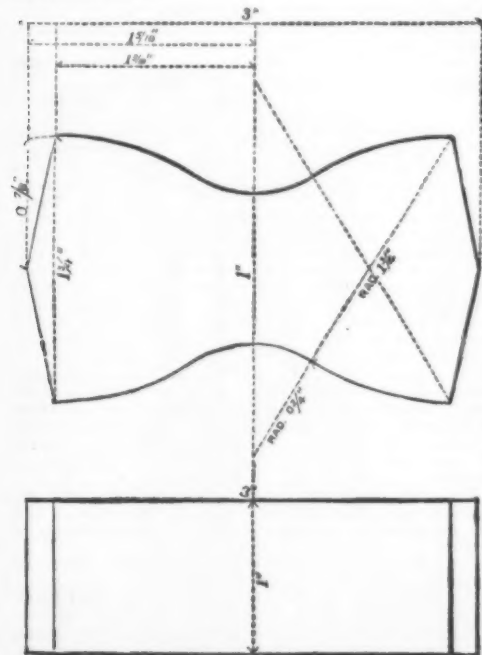


FIG. 1.—DETAILS FOR BRIQUETTE AS RECOMMENDED BY THE COMMITTEE ON A UNIFORM SYSTEM FOR TESTS OF CEMENT.

For sand, two sieves are recommended, viz.:

No. 30 (400 meshes to the square inch), wire to be of No. 28 Stubs' wire gauge.

No. 30 (900 meshes to the square inch), wire to be of No. 31 Stubs' wire gauge.

These sieves can be furnished in sets as follows, an arrangement having been made with a manufacturer*

* Williams' Globe Wire Works, 25 Fulton Street, New York City.

of such articles, by which he agrees to furnish them of the best quality of brass wire cloth, set in metal frames, the cloth to be as true to count as it is possible to make it, and the wire to be of the required gauge. Each set will be inclosed in a box, the sieves being nested.

Set A, three cement sieves, to cost \$4.80:

No. 100.....	7 inches diameter.
No. 74.....	6 1/2 " "
No. 50.....	6 " "

Set B, two sand sieves, to cost \$4.00:

No. 30.....	8 inches diameter.
No. 30.....	7 1/2 " "

STANDARD SAND.

The question of a standard sand seems one of great

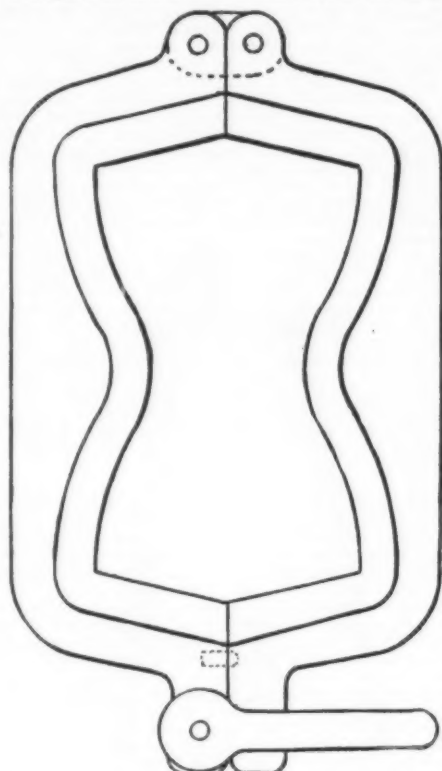


FIG. 2.—STANDARD FORM FOR MOULD.

importance, for it has been found that sands looking alike and sifted through the same sieves give results varying within rather wide limits.

The material that seems likely to give the best results is the crushed quartz used in the manufacture of sandpaper. It is a commercial product, made in large quantities and of standard grades, and can be furnished of a fairly uniform quality. It is clean and sharp, and although the present price is somewhat excessive, (3 cents per pound), it is believed that it can be furnished in quantity for about \$5.00 per barrel of 300 pounds. As it would be used for tests only, for purposes of comparison with the local sands, and with tests of different cements, not much of it would be required. The price of the German standard sand is about \$1.25 per 112 pounds, but the article being washed river sand is probably inferior to crushed quartz. Crushed granite could be furnished at a somewhat less rate than quartz, and crushed trap for about the same as granite, but no satisfactory estimate has been obtained for either of these.

The use of crushed quartz is recommended by your committee, the degree of fineness to be such that it will all pass a No. 20 sieve and be caught on a No. 30 sieve. Of the regular grade, from 15 to 37 per cent. of crushed quartz No. 3 passes a No. 30 sieve, and none of it passes a No. 50 sieve. As at present furnished, it would need resifting to bring it to the standard size; but if there were sufficient demand to warrant it, it could undoubtedly be furnished of the size of grain required at little, if any, extra expense.

A bed of uniform, clean sand of the proper size of grain has not been found, and it is believed that to wash, dry, and sift any of the available sands would so greatly increase its cost that the product would not be much cheaper than the crushed quartz, and would be much inferior to it in sharpness and uniform hardness of particles.

MOULDS.

The moulds furnished are usually of iron or brass, the price of the former being \$3, and of the latter \$3 each. Wooden moulds, if well oiled to prevent their absorbing water, answer a good purpose for temporary use, but speedily become unfit for accurate work. A cheap, durable, accurate, and non-corrodible mould is much to be desired, but is not yet upon the market. Figures 1 and 2 show the form of briquette and of metal mould recommended. It may be added that your Committee are not in entire accord with respect to the merits of this form of briquette, its principal defect being that the rupture must take place at the neck or smallest section, whether the strain be one of extension only or otherwise. With a briquette of such form that oblique strains would usually produce rupture in oblique directions, the trials taking this character would be rejected, and the accuracy of the results correspondingly increased thereby.

CLIPS.

In using the clips recommended in the preliminary report, it was found in some instances that the specimens were broken at one of the points where they were held. This was undoubtedly caused by the insufficient

surface of the clip, which, forming a blunt point, forced out the material. Where the specimens were sufficiently soft to allow this point to be embedded, they broke at the smallest section; but when hard enough to resist such embedding, they showed a wedge shaped fracture at the clips. To remedy this, the point should be slightly flattened so as to allow of more metal surface in contact with the briquette. Clips made in this way have been used, and good results obtained.

To adopt the one inch clips of the Riehle machine, only a slight amount of work is necessary; the ends being rounded as shown in Figure 3 will admit the proposed new form of briquette, and yet not prevent the use of the old one, thus allowing comparative tests of the two forms to be made without changing the clips.

There should be a strengthening rib upon the outside of the clips, as shown in Figure 3, to prevent them from bending or breaking when the specimens are very strong.

The clips should be hung on pivots so as to avoid as much as possible cross strain upon the briquettes.

MACHINES.

No special machine has been recommended, as those in common use are of good form for accurate work, if properly used, though in some cases they are needlessly strong and expensive. Machines with spring balances are to be avoided as more liable to error than others.

It is by no means certain that there exists any great difference in well-made machines of the standard forms given.

The experiments of the committee do not seem to justify an expression of preference for any one machine.

AMOUNT OF MATERIAL.

The amount of material needed for making five briquettes of the standard size recommended is, for the neat cements, about one and two-thirds pounds; and for those with sand, in the proportion of three parts of sand to one of cement, about one and one-quarter pounds of sand and six and two-thirds ounces of cement.

All of which is respectfully submitted.

Q. A. GILLMORE, Chairman.

D. J. WHITTEMORE,	F. O. NORTON,
J. HERBERT SHEDD,	W. W. MACLAY,
ELIOT C. CLARKE,	LEONARD F. BECKWITH,
ALFRED NOBLE,	THOS. C. MCCOLLOM.

THE COCHINEAL INDUSTRY IN GUATEMALA.

THE following paragraphs describing a visit to a "cochineal range" in Guatemala are taken from the *Montreal Daily Star*:

"In this queer country the raising of hemipterous insects of the bark-lice family—especially the *Coccus cactus* or Spanish cochinilla—is a profitable if not a pleasant industry. In this portion of Guatemala vast plantations are given up entirely to the cultivation of

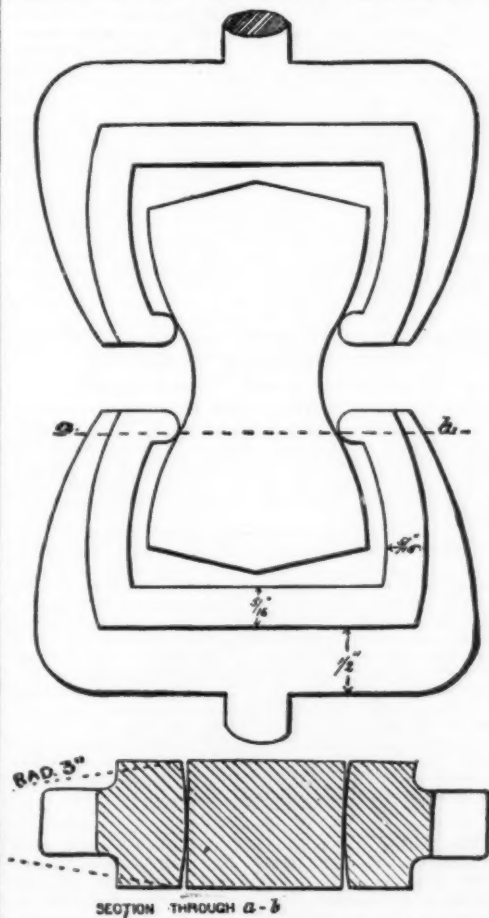


FIG. 3.—STANDARD FORM FOR BRIQUETTE AND CLIPS.

the 'Indian fig,' or nopal, of the genus *Cacti* (*Opuntia cochinillifera*), upon which these bark-lice feed.

"Senor Espanosa's plantation of *Opuntia cochinillifera*, which was the one we visited, includes nearly a thousand acres, and the *modus operandi* of cultivating the insect is most curious. They require about the same care that is ordinarily bestowed upon silk worms, and the occupation is not more disagreeable among crawling bugs than wriggling worms. Immediately before the annual time of violent rains, great branches

of the nopal, covered with insects, are cut off and stored in a building erected for the purpose, to protect them from the weather. At the close of the wet season, four or five months later (about the middle of October), the plantations are again stocked from these supplies, by suspending little nests made of henequin, maguey, jute, or any sort of woody fiber, upon the spines of the growing cacti, each nest containing about a dozen females. Warned by the tropic sun, the insects soon emerge from their semi-comatose condition, and begin to lay eggs with marvelous rapidity, each female producing more than a thousand young. These spread over the plants with marvelous celerity, the young females attaching themselves to the leaves and immediately swelling to incredible size, adhering so closely to the nopal as to become almost a part of it, resembling vegetable excrescences rather than animated creatures.

"In this condition they are gathered for cochineal, none but the pregnant females being valuable for commercial purposes. The males are comparatively few in number—not more than one to two hundred and fifty females—and are of no use for coloring purposes; but, as in the higher orders of existence, escape most of the pains and perils of life. While the males are thus left to disport themselves undisturbed, the females are picked off with a blunt knife, collected into baskets, and killed by dipping them into boiling water or baking them in a heated oven or on plates of hot iron. The first crop is gathered about the middle of December, and subsequently several more of as many successive generations—the last for the year being late in May. These tiny insects, of the family *Coccidae*, are in the form of rounded scales, the body covered with deep, transverse wrinkles, abdomen of dark mulberry color, with short, black legs, and bristly on the posterior part. The male has two erect wings, the female none.

"A laborer of ordinary skill can pick only about two ounces of cochineal bugs in a day. These lose at least two-thirds of their weight in the process of drying. As it requires no less than seventy thousand insects to weigh a pound, and the average retail price of cochineal is only sixty cents per pound, it may be inferred that the business is by no means a sinecure. By the method of immersing the insects in boiling water they turn to a reddish-brown hue, losing much of the white powder with which the wrinkles of their bodies are loaded. When dried in an oven they retain this, and then their color is gray, and when killed on hot iron they become black. This is the cause of the varieties known in the market as 'silver grains,' 'black grains,' and 'foxy,' the latter (killed by the first plan) being preferred. When dried, the cochineal presents the form of convex grains, each about an eighth of an inch in diameter, with the transverse wrinkles still visible.

"An inferior quality of insects, called *sylicestre*, which is indigenous to a wild species of cactus, is frequently gathered and sold for the better variety, and sometimes the species become mixed without design on the part of the planter. Occasionally a bug distemper breaks out and devastates entire plantations, as in Guatemala a few years ago, when the haciendados were obliged to clean out the old stock, root and branch, and begin anew. The *Coccus cacti* are also fed upon by birds, mice, and the larvae of other insects—the latter destroyers sucking out their bodies and leaving only the empty skins."

(Continued from SUPPLEMENT, No. 525, page 8883.)

THE MANUFACTURE OF TOILET SOAPS.

By C. R. ALDER WRIGHT, D.Sc., F.R.S., F.C.S.

LECTURE III.

THE "fatty acid titration process" consists in determining the total alkali present in a known weight of soap, then separating the fatty and resinous acids therefrom and dissolving them in alcohol, and finally titrating the solution with alcoholic soda or potash solution, using phenol phthalein as indicator, the difference between the two titrations representing the "free alkali." Like all differential methods, the experimental error is large: so much so that, according to our experience, the possible error in such a determination may often exceed two or three per cent. of the amount of combined alkali, although the average of a number of determinations by this process is sensibly the same as the average of valuations of the same samples made by the alcohol test.* When the fatty acids of coconut oil, or other acids somewhat soluble in water, are contained in the soaps, an error of excess in the "free alkali" found may readily be brought about by incomplete collection of every trace of fatty acid owing to partial solubility. On account of the largeness of the probable error of this process, it is not to be recommended for the valuation of toilet soaps, in the better class of which the extreme limits of free alkali permissible do not exceed the amount possibly due to experimental error when this process of testing is employed; for household or laundry soaps, usually containing a considerable excess of alkali, it is sufficiently accurate to be of considerable practical use.

The "salting-out test" is even more apt to give fallacious indications; it is performed by dissolving a known weight of soap in water, and adding salt or saturated brine to the whole (or an aliquot part) of the solution, so as to throw out of solution a curd from which the aqueous liquid is separated by filtration; the alkalinity of this filtrate is then determined by standard acid, and reckoned as the "free alkali" contained in the soap. In thus operating, the sources of error are manifold, the tendency being almost invariably to over-estimate the free alkali. First, with certain kinds of soaps, notably those containing coconut oil acids, the addition of salt in quantity short of saturation may fail to throw out of solution all fatty acids as soaps, so that a small amount of soap remains dissolved. Secondly, even when this source of error is avoided (either by addition of a saturating amount of solid salt, or preferably by evaporation of the filtrate to dryness and taking up with just sufficient water to dissolve the saline matters, and filtering from flakes of soap thus rendered insoluble), another is usually introduced, due to the fact that solution in water more or less decomposes neutral soaps into acid ones and free alkali, so

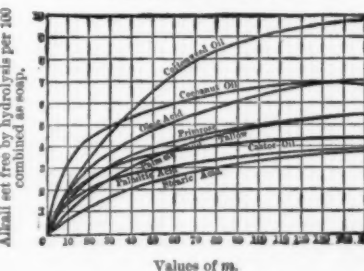
that the curd thrown out of solution retains somewhat less alkali combined with the fatty acids than corresponds with neutral soap, while the filtrate contains the balance, together with that originally present in the soap in excess of the neutralizing amount. Thirdly, it is not practicable to introduce a satisfactory correction for the excess of alkali thus indicated by the "salting-out test," because not only does each kind of soap decompose to a different extent by treatment with a given quantity of water, but also the amount of decomposition (or hydrolysis, as it may be conveniently termed) is variable with the relative quantity of water used, increasing as the amount of water increases; further, the amount of hydrolysis effected by a given proportion of water acting on a soap made with a given kind of fatty acid is variable with the amount of alkali present in the "free" state in the original soap, so that while such a soap will, when neutral, become hydrolyzed to a marked extent under given conditions, the hydrolysis may be greatly lessened or even stopped altogether by adding a small amount of free alkali to the solution before salting out. For all these reasons it is evident that the "salting-out test" cannot be recommended for the valuation of toilet soaps in which the presence of only minute quantities of free alkali is baneful, inasmuch as the possible error is far too great; but, like the "fatty acid titration process," this test is often of considerable practical value in the examination of the commoner kinds of soaps, more especially the strongly alkaline classes intended for scouring and general household purposes.

In connection with this point the following experimental results obtained by us may be quoted, being the average values deduced in a lengthy series of experiments on the amounts of hydrolysis effected when varying proportions of water are used to dissolve soda soaps made from fatty acids of the most frequently employed kinds. In all these experiments the soaps employed were either exactly neutral or only faintly alkaline, so that no perceptible diminution in the amount of hydrolysis was occasioned by the presence of excess of alkali in the soaps. The numbers represent the quantities of alkali set free by treatment of one part by weight of anhydrous soap with *m* parts of water, calculated per 100 parts of alkali contained in the soap combined with fatty acids. The soaps employed were either prepared by ourselves or were obtained from manufacturers, with information as to the nature of the materials from which they were made, and subsequently analyzed.

Soaps Prepared from	Hydrolysis brought about by <i>m</i> Parts of Water.					
	<i>m</i> =10	<i>m</i> =15	<i>m</i> =25	<i>m</i> =50	<i>m</i> =100	<i>m</i> =150
Pure stearic acid.....	0.75	1.0	1.5	2.4	3.4	3.8
Nearly pure palmitic acid.....	1.5	1.8	2.8	3.0	3.5	3.9
Crude lauric acid (coconut oil soap).....	3.5	4.0	4.7	5.7	6.75	7.0
Pure oleic acid.....	2.1	2.6	3.5	4.75	6.3	7.1
Crude ricinoleic acid (castor oil soap).....	1.75	2.25	2.75	3.6	4.3	4.6
Palmitic, stearic, and oleic acids, in nearly equal proportion (palm oil and tallow soap).....	1.2	1.5	2.25	3.75	5.0	5.6
Tallow resin soap (primrose).....	1.7	2.2	2.9	4.0	5.0	5.6
Cottonseed oil soap.....	2.25	2.8	4.2	6.5	9.0	9.8

The diagram below represents these values as curves, the values of *m* being abscissæ and the others ordinates. It hence appears that, with neutral soaps, the amount

Hydrolysis brought about by *m* parts of water for 1 part of anhydrous soap.



of hydrolysis brought about by using 10 parts of water to dissolve 1 of anhydrous soap may vary from 0.75 to 3.5; with 25 parts of water, from 1.5 to 4.7; with 100 parts, from 3.4 to 9.0, and so on, quantities ranging between far too wide limits to make it practicable to deduce any average values applicable generally as corrections to be applied to the results of the salting-out test. Further, the following values obtained with some of the above soaps, to which a small excess of alkali was added, show that the correction applicable to a neutral soap would be too large to apply to an alkaline one.

Soaps Prepared from	Extra Alkali added per 100 Combined Soap.	Hydrolysis brought about by <i>m</i> Parts of Water.			
		<i>m</i> =10	<i>m</i> =15	<i>m</i> =25	<i>m</i> =150
Crude lauric acid (coconut oil soap).....	11.0	1.0	1.15	1.5	1.5
Cottonseed oil soap.....	15.0	nil.	nil.	0.9	1.5
Tallow resin soap (primrose).....	15.0	nil.	0.1	1.5	1.5
	20.0	nil.	nil.	nil.	nil.

A number of commercial toilet soaps were analyzed, using simultaneously the alcohol test and the salting-out test, employing about 10 parts of water for 1 of anhydrous soap (from 5 to 9 parts for 1 of actual moist soap, according to its humidity). On the whole, it was found that in those soaps containing but little or no coconut oil acids, the two tests, when applied to soaps not containing more than 5 parts free alkali per 100 combined, usually differed by about 1.0 to 2.0, quantities fairly in accordance with the hydrolysis values above described for this class of soaps; while, when large amounts of coconut oil acids were present, somewhat greater differences, usually about 2.0 to 3.0, were

observed, again agreeing with the above higher values for the hydrolysis of coconut oil soap.

These experiments lead to one notable conclusion, viz., that the use of soaps absolutely devoid of free alkali in the solid state, or very nearly so, is not attended with quite so much advantage to the user as might at first sight be expected; for, when brought into contact with water, a certain amount of free alkali is generated, even were none present originally. Apart, however, from the fact that the alkali thus set free becomes more or less neutralized by acid matters naturally present adhering to the skin,* the cleansing effect of soap being largely due to this action, it is obvious that the alkali thus set free cannot be large in amount; the film of water adhering to the skin may perhaps weigh 10 or 20 times as much as the soap abraded from the tablet, and consequently with a toilet soap of good quality may possibly set free something like 2.0 per cent. of the alkali contained in this abraded soap. Taking this figure, it would result that four soaps containing respectively 0.10, 2.0, 3.0, and 5.0 of free alkali per 100 combined would develop lathers respectively containing 2.0, 3.0, 4.0, and 5.0 of free alkali; so that, in fine, whether a soap be absolutely neutral or contain a small amount of free alkali (not exceeding, say, 2 per cent. of the alkali combined as soap) is not a matter of such great consequence as it would at first sight appear. It is to be noticed, however, that practical experience leads persons possessing sensitive skins to eschew all soaps containing more free alkali than a very few per cents. of the amount present as soap, inasmuch as these alkaline soaps, when habitually used, cause a considerable amount of irritation and discomfort; while careful analysis shows, as will be more fully discussed later on, that the most highly esteemed skin soaps prepared by the best makers (which soaps do not by any means necessarily mean the most delicately scented soaps prepared by perfumers, these being often objectionably alkaline) do not contain more free alkali than about one-fortieth part (2.5 per cent.) of the alkali present combined as soap.

Combined Alkali.—When the total alkali present in a given sample of soap has been determined, and the "free alkali" (by the alcohol test), the amount of alkali actually present as neutral soap is known, being the difference between the two amounts. The determination of this quantity, and of the amount of "fatty acids" yielded by the soap on treatment with acid as above described, leads to some valuable information concerning the quality of the soap, giving the means of calculating the actual percentage of soap present (apart from water, etc.), and also furnishing some knowledge concerning the nature of the fatty matters used in making the soap.

The percentage of actual soap present is not the same thing as the sum of the alkali contained as soap, and the fatty acids (corrected for unsaponified fat, etc.) as thus deduced, on account of the water taken up in decomposing the soap by the test acid. Supposing that A represents the percentage of fatty acids, B that of anhydrous soda (Na_2O) contained combined as soap, and C that of anhydrous potash (K_2O) similarly contained, then S, the percentage of actual soap, is given by the equation:

$$S = A + B + C - \frac{2}{3}B - \frac{1}{4}C = A + \frac{1}{3}B + \frac{1}{4}C.$$

If the soap be a pure soda soap, or if the amount of potash in it be but small, so that the total alkali may be reckoned as soda without material error, the value of the term $\frac{1}{4}C$ lies usually between 0.030 \times A and 0.045 \times A, according to the nature of the fatty acids, the smaller figure corresponding with acids of comparatively high molecular weight, such as arachidic acid ($\text{C}_{26}\text{H}_{52}\text{O}_2$) and stearic acid ($\text{C}_{18}\text{H}_{36}\text{O}_2$), and the latter with acids of low molecular weight, such as those of coconut oil (mean molecular weight near that indicated by $\text{C}_{13}\text{H}_{26}\text{O}_2$). As the former acids predominate in most opaque toilet soaps, the value 0.035 A may be taken in most cases as sufficiently nearly exact for this class of soaps; whence

$$S = A - 0.035 A + B = 0.965 A + B.$$

In the case of transparent soaps made without spirit, however, the proportion of coconut oil employed is usually sufficiently great to make $\frac{1}{4}C$ B more nearly equal to 0.40 A, whence

$$S = A - 0.04 A + B = 0.96 A + B.$$

From the percentages of combined alkali and of fatty acids formed on decomposing the soap by a mineral acid, the mean molecular weight or combining number of the fatty acids is deducible; and the numerical value thus obtained, together with the melting point, sp. gr., and general characters of the fatty acids, often leads to information as to the nature of the fats and oils used in making the soap. If *x* be the mean combining number, A the percentage of fatty acids present combined as soap, and B the percentage of combined alkali expressed as anhydrous soda, Na_2O , then:

$$x = \frac{A}{B} \times 31.$$

The following table exhibits the values of *x* pertaining to various pure fatty acids and ordinary oils and fats, the latter being deduced from experiments in my own laboratory; very similar figures have also been obtained by other experimenters:

Acid.	Formula.	Molecular weight.
Brassic.....	$\text{C}_{22}\text{H}_{44}\text{O}_2$	336
Arachidic.....	$\text{C}_{26}\text{H}_{52}\text{O}_2$	396
Ricinoleic.....	$\text{C}_{18}\text{H}_{34}\text{O}_2$	298
Stearic.....	$\text{C}_{18}\text{H}_{36}\text{O}_2$	284
Oleic.....	$\text{C}_{18}\text{H}_{34}\text{O}_2$	282
Palmitic.....	$\text{C}_{16}\text{H}_{32}\text{O}_2$	256
Lauric.....	$\text{C}_{12}\text{H}_{24}\text{O}_2$	200
Fatty acids from tallow, lard, olive oil.....	Chiefly $\text{C}_{13}\text{H}_{26}\text{O}_2$ and $\text{C}_{15}\text{H}_{30}\text{O}_2$	278 to 286
Fatty acids from castor oil.....	Chiefly ricinoleic, $\text{C}_{18}\text{H}_{34}\text{O}_2$	298 " 299
" " " coconut oil.....	Lauric acid $\text{C}_{12}\text{H}_{24}\text{O}_2$, O_2 , with higher and lower homologues	196 " 304
" " " palm oil mixed with tallow.....	$\text{C}_{12}\text{H}_{24}\text{O}_2$, $\text{C}_{14}\text{H}_{28}\text{O}_2$, O_2 , and $\text{C}_{16}\text{H}_{32}\text{O}_2$	280 " 289

* A moistened blue litmus paper pressed on the skin is usually reddened by the action of perspiration acids.

† Many analysts use the constant factor 0.97; this materially overstates the fatty anhydrides actually present. Thus, a pure coconut oil giving the values A = 50, B = 7.5, gives with this factor S = 5.25, while the true value is 22.

S = A + $\frac{B}{31}$ = 55.5, or — = 14 per mille lower.

* In a series of check experiments, soaps of perfect neutrality were found, when examined by the fatty acid titration process, to indicate amounts of free alkali varying from +2 or 3 or even more parts per 100 of alkali combined as soap to — values of about the same magnitude, the latter result apparently indicating excess of fatty acids.

Soaps made from the class of fatty matters ordinarily used for the better classes of toilet soaps yield on decomposition fatty acids, the mean molecular weight of which is always above 250, generally above 275, and often above 280, when coconut oil is not one of the ingredients; when this oil is employed to any marked extent, the molecular weight is depressed in proportion to the quantity used. Opaque soaps of good quality rarely contain so much coconut oil as to reduce the mean molecular weight below 245 or 250; but transparent soaps made without alcohol generally contain so large a proportion of coconut oil as to give a mean molecular weight below 230, and often below 220.

The presence of large quantities of coconut oil in a toilet soap is, in England, generally considered objectionable, partly on account of the fact that unless certain special methods are adopted in the treatment of this oil, the soaps made from it are apt to possess an unpleasant odor, which is communicated (often in an intensified form) to the skin or to articles washed therewith; partly because coconut oil requires a somewhat different strength of alkaline lye to effect saponification from that requisite for boiled eurd soaps, and in consequence is generally made strongly alkaline; and partly because coconut oil soap possesses to a greater extent than almost any other the property of giving a fairly hard mass even when large quantities of water are present, provided that a certain proportion of saline matters are introduced to "close up" the mass; so that perfumers and others using coconut oil soaps as an ingredient in a blended mass prepared by milling or remelting often turn out a finished product containing an undue proportion of free alkali or saline matters. Most of these objections, however, do not necessarily apply to an article made with due attention to certain details in the preparation (the knowledge of which, however, does not appear to be possessed by every maker); accordingly, a certain proportion of coconut oil is often to be found in some of the highest class of Parisian soaps, a ready capability of lathering and other advantages being gained by its presence without any marked counterbalancing disadvantages, as long as the necessary precautions to avoid them are taken.

Determination of Glycerin.—The accurate determination of the quantity of glycerin present in a sample of soap is not always easy, especially when sugar is also present. The method usually prescribed is to dissolve a known weight of soap in water, acidulate (preferably with sulphuric acid), filter from separated fatty acids, neutralize with carbonate of soda, evaporate to dryness, and treat the residue with strong alcohol, which dissolves glycerin and leaves behind sodium salts. The residue left on evaporation to dryness of the alcoholic solution is rarely pure, most soaps containing small quantities of substances derived from the original oils and fats which are not insoluble in the acidified aqueous fluid, and thus become more or less dissolved out by the alcohol, so that soaps containing no trace of glycerin will still furnish small percentages of alcoholic extract when thus treated. Chloride of sodium, too, being slightly soluble in ordinary alcohol, may be contained in the extract. By redissolving the dried extract in absolute alcohol and adding one and a half times its volume of ether, a certain amount of substances other than glycerin is generally precipitated; but in most cases even this purification fails to yield pure glycerin, especially in presence of sugar. A fairly accurate valuation of the amount of glycerin present in the extract may be obtained by rendering it strongly alkaline with aqueous caustic soda, and then dropping in dilute copper sulphate solution with agitation, until the copper hydroxide thus formed begins to fail to dissolve; the filtered blue solution is compared colorimetrically with a known quantity of a standard solution of glycerin treated side by side in the same way. When sugar is present, the alcoholic extract must be treated with dilute sulphuric or other acid for some time, so as to "invert" the sugar, the fluid being then rendered alkaline, and copper sulphate dropped in boiling as long as suboxide of copper is reduced, after which the colorimetric estimation of the glycerin is proceeded with as before, the comparison being preferably made with a known solution of glycerin and cane sugar treated side by side with the sample tested. With care and practice fairly good results can be thus obtained, more especially when sugar is absent. The following figures illustrate the numbers obtained in analysis for glycerin, the values being percentages:

Nature of Soap examined.	Glycerin in alcoholic extract.	Extract precipitated by ether.	Glycerin in alcohol after treatment by copper test.
An opaque tinted soap of moderate quality.	70	61	60
A higher class Parisian soap sold as a glycerin soap, not transparent.	81	70	80
A cold process soap containing much unsaponified fat.	66	49	47.5
A British so-called "glycerin" soap; opaque.	79	79	06
Another, ditto.	77	67	04
Another, ditto.	075	043	nil.
A British transparent soap, not containing sugar.	190	170	150
Another ditto, containing upward of 10 per cent. of sugar.	61	40	nil.

The entire absence of glycerin from a toilet soap necessarily proves that the whole mass has been prepared either by a boiling process or by saturating a free fatty acid (e. g., oleic acid) with alkali, or by both processes combined, while, on the other hand, the presence of a quantity not far removed from the percentage of combined alkali (expressed as Na_2O) suggests that the whole has been probably prepared by a cold process; for as ordinarily oils and fats are substantially triglycerides, one equivalent of fatty matter will yield 92 parts of glycerin and fatty acids, equivalent to 93 of Na_2O . When larger quantities of glycerin are present, extra glycerin must have been added to the materials during manufacture; when small quantities

only are present, constituting only a fraction of the percentage of combined alkali (expressed as Na_2O), the soap is probably a blended mass, consisting partly of boiled and partly of cold process soaps.

CLASSIFICATION OF TOILET SOAPS IN ACCORDANCE WITH THE RESULTS OF CHEMICAL ANALYSIS.

It has already been repeatedly noticed that the prevailing fault of a very large proportion of British toilet and fancy soaps is that they contain such quantities of "free alkali" as to render them decidedly injurious to tender and sensitive skins when habitually used. Although the general public has not as yet been thoroughly "educated up" to the point of appreciating the magnitude of this evil, yet most persons whose skins are extremely sensitive find by experience, in winter or during the prevalence of easterly winds, that frequent washing with soap and water is impossible without producing much personal discomfort, unless they use selected kinds of soap to which experience has guided them. Many such persons discard soap altogether in favor of materials like oatmeal and certain vegetable creams and other cosmetics which do not contain alkaline matters.

As regards the injurious effects of soaps containing free alkali on persons possessing sensitive skins, there is a general consensus of opinion among those hygienists and specialists in skin diseases who have carefully studied the matter, that such is actually the case to a far greater extent than is suspected by the general public. As representing such opinions, the following remarks may be quoted, by Mr. J. L. Milton, senior surgeon to St. John's Hospital for Diseases of the Skin: "Most toilet soaps . . . contain too much alkali, not, perhaps, an object of much importance to persons with hard, strong skins, but of great consequence when this organ is sensitive or out of order; and we constantly have cases of relapse at the hospital from the use of alkaline soaps for domestic purposes." Plenty of other medical testimony to the same general effect might be also quoted did time permit.

In view of the objectionable effects produced by excess of alkalinity in toilet soap, and of the circumstance that the best British and foreign makes are found by analysis to contain only very small quantities of free alkali, expressed as anhydrous soda, Na_2O , not exceeding 0.20 to 0.25 per cent, by weight (the combined alkali being usually about 7 to 9 per cent., or some forty times as much), I am disposed to classify toilet soaps into three grades, from the point of view of the amount of free alkali present, viz.:

First Grade.—Soaps which are, if not actually neutral, at any rate so far devoid of free alkali that the amount of total alkaline matter present in forms other than actual soap does not exceed one-fortieth part (2.5 per 100) of the alkali present combined with fatty acids as soap.

Second Grade.—Soaps in which the free alkali, although exceeding one-fortieth part (2.5 per 100) of that combined as soap, does not overpass three-fortieths of that amount (7.5 per 100).

Third Grade.—Soaps in which the free alkali exceeds three-fortieths (7.5 per 100) of the alkali combined as true soap.

The chief reason for drawing the line of demarcation between second and third class soaps (as regards free alkalinity) at the point named, viz., three-fortieths of the combined alkali, is that during the last five years I have noticed, in members of my own family and friends possessing sensitive skins, that the use for a short time of a toilet soap containing sufficient free alkali to bring it into the third grade as thus defined has almost invariably caused a considerable amount of inconvenience and discomfort, even when the nature of the fatty acids present was not in any way objectionable. Of course, however, the precise position of the boundary line is open to discussion, and the fixing it at the point named is a matter of personal opinion. I believe, however, that in practice the above figures will be found to represent fair standards of character.

As regards the third grade of soaps as thus defined, it is noticeable that it includes, not only nearly all the transparent soaps made without alcohol that have come under my notice (probably on account of the use of excess of caustic alkali in the first instance, to insure complete saponification and transparency, or the addition of soda crystals as a hardening and "closing up" agent), but also a not inconsiderable number of soaps made by perfumers (probably by the cold process), and usually deliciously scented, and in consequence sold at prices that might be expected to be a guarantee of high quality; so that high price alone is by no means necessarily a criterion of excellence, although it is certainly true that no article can possibly be made at a low price combining simultaneously the various requisites of choiceness of materials, freedom from alkalinity, elegance of finish, and delicacy of perfume.

It is obvious that it does not follow that a soap is of high quality as a toilet soap simply because it is practically free from excess of alkali, although the converse is true, viz., that a soap is entirely unsuited for application to the skin when it contains much of that constituent, no matter how excellent it may be in other respects. In short, a toilet soap, to be of the first class from all points of view, must possess the following qualities: First and foremost, it must contain practically no free alkali; secondly, it must be made from materials free from all trace of rankness, coarseness, or rancidity, i. e., the fatty matters and oils, etc., used in its preparation must be of best quality, carefully selected; further, it should not be liable to discolor or brown to any great extent on keeping; for this change of color is accompanied by oxidation (as evidenced by the fact that the discoloration commences from the outside by contact with air), the effect of which is sometimes to produce a change in the soap akin to that termed rancidity in an oil, accompanied by the development of an unpleasant odor; soaps which have undergone this change occasionally acquire the power of injuriously affecting sensitive skins, causing blotching and irritation, even though free from excess of alkali to any marked extent. Again, to be of high quality, a toilet soap cannot contain large percentages of water;

* It seems very probable that this browning and decomposing action is due to the presence of small amounts of nitrogenous matter; it is often noticed in soaps made from tallow, especially of inferior grades, and in fact is so marked as to be one leading cause why toilet soaps are usually tinted red, brown, or orange, in preference to blue, mauve, or green, the latter colors becoming far more muddy and dirty looking on keeping than the former, owing to the spontaneous browning of the soap itself.

for this entails the use of saline matters to "close up" and harden the mass, and these, if present in any quantity, are not unlikely to affect the skin injuriously. Further, if tinted, or "medicated" by intermixture with non-saponaceous matters, such as thymol, vaseline, sulphur, etc., the soap must not contain any compounds capable of causing irritation, and especially should be free from poisonous metals, and notably from mercury, lead, copper, and arsenic, while, to give satisfaction to purchasers, it must not be liable to melt away rapidly even in hot water, and must lather freely, giving a bland, emollient feel during use. Unless a soap can pass all these tests satisfactorily, it cannot be regarded as a first-class article. If defective in one or more vital points, it can only be assessed as second-class; and if defective in many, as third-class.

(To be continued.)

CALORIFIC POWER OF FUEL.

By JOJI SAKURAI, Professor of Chemistry, Tokio University, Japan.

In Watts' Dictionary, vol. ii., there is an excellent article on "Fuel," written by Dr. Benjamin H. Paul, where a method for calculating the calorific power of fuel is given. Thus, after speaking of the relative calorific power of hydrogen and carbon, and of the effects of oxygen contained in a fuel, he says on page 723:

"The relative calorific power of fuel may be calculated by means of the following formulae, in which p represents the relative calorific power, and C, H, O, represent the amounts of carbon, hydrogen, and oxygen in one part of the fuel:

1. Fuel containing only carbon $p = C$.
2. Fuel containing carbon and hydrogen $p = C + 4.265 H$.
3. Fuel containing carbon, hydrogen, and oxygen $p = C - \frac{8}{3} O + 4.265 H$ or $p = C + 4.265 (H - \frac{1}{4} O)$.

"If it is desired to express the calorific power of fuel in heat units, the amount of carbon and the amount of available hydrogen in one part of the fuel are to be respectively multiplied by the numbers expressing the calorific power of carbon and of hydrogen, and the sum of the two products represents the calorific power of the fuel in heat units:

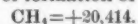
1. $p = 8080 C$.
2. $p = 8080 C + 34462 H$.
3. $p = 8080 C + 34462 (H - \frac{1}{4} O)$.

Then he gives a table in which the relative calorific powers of several combustibles are given, as calculated from their composition according to the above formulae, and from which I here reproduce a few figures:

Fuel.	Composition of Fuel.				Calorific Power in Heat Units.
	Carbon.	Hydrogen.	Oxygen.	Ash.	
Hydrogen	—	1.000	—	—	34,462
Marsh gas	0.750	0.250	—	—	14,675
Olefiant gas	0.857	0.143	—	—	11,849
Av. Welsh coal	0.838	0.048	0.041	0.000	8,241

The number 14,675, which is the sum of the quantities of heat evolved by carbon and hydrogen separately, is therefore regarded as the relative calorific power of marsh gas, a view which is similar to stating that marsh gas is a mixture of carbon and hydrogen.

As every one knows, the researches of Thomsen and Berthelot have shown us that the calorific power of a hydrocarbon is not equal to the sum of the quantities of heat evolved by the carbon and the hydrogen separately; that, in fact, we must take into account the heat which is evolved or absorbed by the separation of carbon and hydrogen from each other. According to Thomsen, the heat of formation of marsh gas is:



This quantity of heat is therefore absorbed during the decomposition of 16 parts of marsh gas into carbon and hydrogen, and hence the actual heat of combustion for 1 part of marsh gas must be about 1,276 units less than the number found in the above table.

Again, when olefiant gas is decomposed into carbon and hydrogen, there is evolved some heat, and hence the actual heat of combustion of that hydrocarbon must be greater than that in the table. According to Thomsen, we have:



Hence, the decomposition of 1 part of olefiant gas into carbon and hydrogen evolves about 389 units of heat, and hence the calorific power of olefiant gas should be 12,238 heat units.

Lastly, coal is evidently not a mere mixture of carbon, hydrogen, etc., but is a chemical compound of some sort, and hence the calculation of its calorific power according to the above formulae is not only useless, but is also erroneous.

There is, so far as I am aware, no formula by which the calorific power of fuel may be calculated. The only way is to resort to actual experiments.

It is unfortunate that no correction has been made in the subsequent volumes of Watts' Dictionary as to the point above referred to; nor has any one, so far as I can ascertain, pointed out the error.

Not only is that the case, but even in some of the very recently published books we read similar statements. For example, on p. 43, part ii., of Mr. C. J. Woodward's excellent little book called "Arithmetical Chemistry," the following statement occurs:

"The calorific power of coal of which the percentage composition is given is calculated in the same way [that is, by adding together the calorific powers of carbon and hydrogen contained in the coal: J. S.], but, of course, any nitrogen or ash the coal may contain must be disregarded; and further, if oxygen be present in the coal, a quantity of hydrogen or carbon, or the two together, sufficient to combine with this oxygen must be deducted."

October 19, 1885.

—Chem. News.

To prevent rust of bright steel goods in show cases which are not air tight. It is well known that the rusting of steel is due to the precipitation of the moisture in the atmosphere upon the metal. This may be obviated by keeping the air surrounding the goods dry by means of a little powdered quicklime placed in a receptacle within the case. The lime will absorb all the moisture. As the lime becomes slaked it will of course be necessary to replace it from time to time with fresh.

* In actual practice, the quantity of glycerin yielded by oils and fats usually falls a little short of that corresponding with a triglyceride, usually 85 to 90 per cent. of that amount, according to my own observations; similar deficiencies appear to have been also noticed by other chemists.

THE DETERMINATION OF PHOSPHORIC ACID IN COMMERCIAL FERTILIZERS.

By JOHN S. ADRIANCE, A.B., F.C.S.

THE value of commercial fertilizers depends partially upon the three forms in which phosphoric acid is found. These are known as soluble, insoluble, and reverted, and they are represented by the formulae $\text{CaH}_2\text{P}_2\text{O}_7$, $\text{Ca}_3\text{P}_2\text{O}_7$, and $\text{Ca}_4\text{H}_2\text{P}_2\text{O}_7$.

A workable method for the determination of phosphoric acid is called for; and I have endeavored to be very explicit in my directions, so that any one of ordinary intelligence may carry on for himself his own estimations, and perhaps check the errors of others.

The sample should be well mixed, so that small portions accurately represent the substance.

Rub and crush the sample in a mortar (taking care not to grind it, as the free acid may render more of the phosphate soluble) until it will pass through a sieve of 144 meshes to the square inch, taking care to thoroughly mix the result.

I. The determination of phosphoric acid soluble in water: Bring 2 grains upon a filter, and wash with 100 c. c. of water, allowing each funnelful to run out before adding more. Transfer the residue to a mortar and rub to a paste, using 100 c. c. of water, return to the filter, and wash until the washings no longer react acid with delicate litmus paper. Mix the washings, and dilute to 300 c. c., taking 100 c. c. for analysis. Boil the solution and add 15 grammes of ammonium nitrate (this assists precipitation). To the hot liquid add 50 c. c. of molybdic solution;* allow the mixture to stand at about 65° C. for two hours. When cold, decant the liquid through a filter and wash with ammonium nitrate solution until ammonia gives no cloudiness, avoiding an excess. Test the filtrate with renewed digestion and addition of more molybdic solution to see if any remains. Dissolve the precipitate on the filter with dilute ammonia (1 to 3), adding no more than just enough to dissolve the precipitate, and wash the filter well with warm water into a beaker to not more than 100 c. c. Nearly neutralize with hydrochloric acid, and when cold add magnesia mixture† slowly, stirring vigorously. After fifteen minutes add 15 c. c. of ammonia of sp. 0.96; and let stand several hours (two hours is usually long enough). The precipitate should be finely crystalline, and not flocculent. Decant and bring the precipitate on a filter. Wash continuously with dilute ammonia (1 to 3), until silver nitrate acidulated with nitric acid gives no cloudiness. Dry and remove the precipitate from the filter to a porcelain crucible, heat gradually, finally using a blast lamp for five minutes. Now add the filter ash, and heat for ten minutes. If the precipitate is not white, add three drops of nitric acid and reignite until weight is constant.

II. Phosphoric acid insoluble in citric acid solution: Wash the residue which remains after the soluble phosphoric acid has been extracted into a 150 c. c. flask with 100 c. c. of ammonium citrate solution.‡ Shred and add the filter paper; cork the flask securely and place in a water bath with constant temperature of 65° C., and digest for thirty minutes, with agitation once in five minutes. Add an equal volume of water and filter the solution quickly, using a filter pump, and wash with water of the ordinary temperature. This filtration should not exceed fifteen to twenty minutes. Transfer the filter and its contents to a small platinum dish, and ignite gently until the organic matter is destroyed. Treat the residue with 15 c. c. of fuming HCl. Digest for fifteen minutes over a low flame, or until the phosphates are dissolved. Dilute to 200 c. c., pass through a dry filter, take 50 c. c. and determine the phosphoric acid as under soluble phosphoric acid.

III. Total phosphoric acid: Take about 2 grammes and mix with 7 c. c. of a saturated solution of magnesium nitrate (which prevents any insoluble phosphoric acid becoming changed to a pyro-phosphate). Ignite, and moisten the residue with nitric acid. Ignite again until all organic matter is destroyed. Treat the residue with 20 c. c. of concentrated HCl, and digest until all the phosphates are dissolved. Dilute to 300 c. c. and pass through a dry filter. Take 50 c. c. of the filtrate, neutralize with ammonia, and determine phosphoric

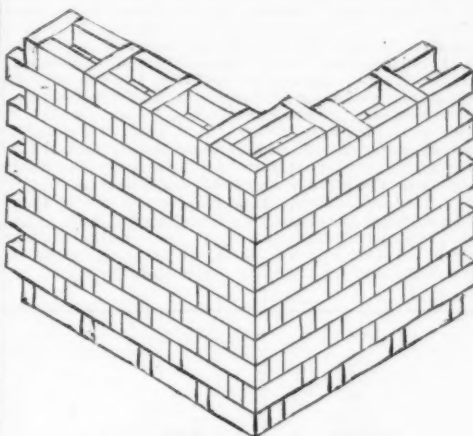
acid as under soluble phosphoric acid. The phosphoric acid soluble in the citrate solution is found by subtracting the sum of the phosphoric acid soluble in water and the phosphoric acid insoluble in the citric acid solution from the total phosphoric acid found, or $S - (a + c)$, where

s = total phosphoric acid,
 a = water soluble,
 c = insoluble in citric acid.

NOTE.—The weight of magnesium pyro-phosphate multiplied by 0.63977 will give the amount of P_2O_5 present. This result divided by the amount of substance taken gives the per cent. of P_2O_5 .

HOLLOW BONDS.

In alluvial districts, where brick walls are almost exclusively used, it often becomes necessary, or at least

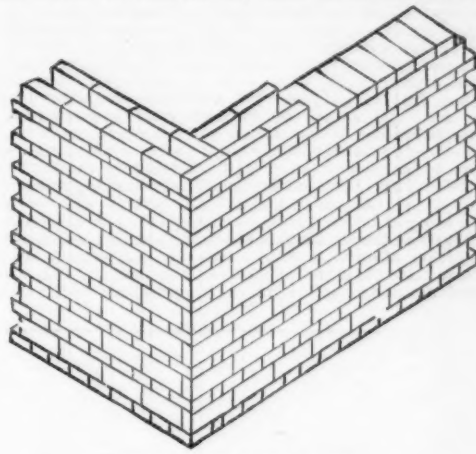


SILVERLOCK'S HOLLOW BOND.

lancet to the wide span arch, which differs but little from a segmental or semicircular. Perhaps one of the most useful and at the same time ornamental of these arches is the "equilateral," so called from its being struck on an equilateral triangle, as shown by the dotted lines in the accompanying sketch at A.

There has been a good deal of discussion among practical men, from time to time, as to the way this arch should be carried out. Of the three methods shown in the illustration, one is probably as often employed as the other.

It may be taken as a general rule in all arch work that the mortar joints should be set out at right angles to tangents of the curve, and in the case of arcs of circles that they should radiate to the centers from which the arcs were struck. Following this rule, we have the arch shown at A. The bricks are set out from the crown (a) with the key brick in the center, the



DEARNE'S HOLLOW BOND.

advisable, to erect a wall at the smallest possible cost. For the cheaper kind of cottage and fence walls, the ordinary methods of carrying out the bonds sometimes become too expensive for the purpose. In such cases builders will often employ inferior bricks and mortar to lessen the cost, with the obvious result that the wall is greatly weakened both in strength and durability.

An excellent method of building non-expensive one-brick walls, and one largely used in some districts, is that of carrying out the hollow bonds of which we show an illustration. Fig. 1 is called "Silverlock's" hollow bond, and is somewhat similar in appearance to the Flemish bond. The bricks are all laid on edge, header and stretcher alternately. Commencing at the quoin, a header is first laid, which, being only 2½ in. wide, instead of the usual 4 in., requires a closer 2½ in. long, followed by header and stretcher to the end. The next course is started with a stretcher followed by a header, with stretcher and header alternately to the end. This method will leave vacant spaces in the interior of the wall and thus save bricks. Of course the strength of the wall is lessened, but the durability and strength will be found to compare very favorably with walls built at the same cost in the ordinary way of inferior bricks.

"Dearne's" hollow bond follows the lines of English bond. Here we have one course commenced with a header followed by a two inch closer, and then headers to the end of the wall, all laid flat in the usual way. The stretcher courses are laid on edge to effect a saving of bricks, as in Silverlock's bond. The wall is stronger than Silverlock's, and takes rather more bricks. For cheap cottage or fence walls, or in any position requiring comparatively little strength, it can be recommended as safe and efficient; and if good bricks are properly laid in really good mortar, it will last almost, if not quite, as long as a solid wall.

These hollow bonds must not be confounded with what are known as hollow walls, in which a hollow space is left in the interior of the wall to keep out the weather and render a building dry. Hollow bonds do not keep out the weather any more than a solid wall; the system can only be applied to 8 inch or one-brick work, and it should only be employed where cheapness is necessary.

A. S. J.

THE EQUILATERAL ARCH.

The pointed arch, one of the distinguishing features of Gothic architecture, varies from the sharp pointed

width of the bricks, 2½ in., being set out on the extrados or outer curve and the joints being taken to radiate to the centers, b and c. The disadvantage of this method is an awkward and unsightly cutting at the crown, which is at the same time a source of weakness. In first-class gauged work, the method should never be used.

To obviate the difficulty of this cutting at the crown, the method shown at B is employed. Here we set off the bricks in the same way as before, commencing with the key brick, and radiating to a point (d) at the center of the span. This is satisfactory so far, and is a method largely used in some parts of the country. The objection is that the mortar joints do not radiate to the arc centers according to rule, and the effect is to apparently increase the height of the arch, which thereby loses its symmetrical proportions.

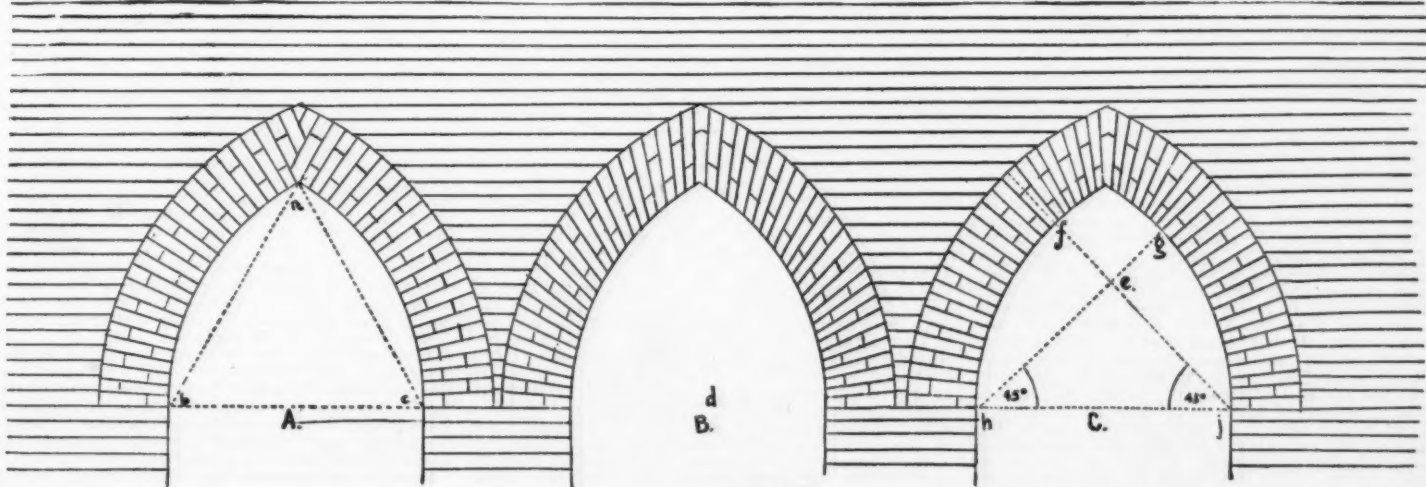
Taking all things into consideration, probably the best method is that shown at C, in which both objections to the other methods are overcome as far as is practicable. The curves are set out in the usual way, and the key brick having been put in and the distances for the bricks stepped off along the extrados, an angle of 45° is set up from each point of the springing, as shown by dotted lines. The mortar joints from h to f and g to j are then taken to radiate to the curve centers, h and j, respectively, and the portion between f and g to the intersection of the dotted lines, e.

There is an objection again to this method, but it is only that the arch takes rather longer to work, by reason of the extra templates required for the bricks at the crown. For arches with large spans the method is to be especially recommended, as it is not only the most symmetrical but, at the same time, undoubtedly the strongest form.

In dealing with pointed arches other than the equilateral, the last method of obtaining the joints may be employed, only that the angle of 45° must be increased or decreased according to the span. The greater part of the mortar joints will radiate to the curve centers, and a few at the crown be eased off in a similar manner.

It will scarcely be necessary to add that in working these gauged arches they will be built of a thickness not exceeding the width of the reveal of the door or window opening, and that a rough arch will be worked on the interior of the wall in the usual manner.

A. S. J.



THE EQUILATERAL ARCH.

* To prepare the molybdic solution, dissolve 75 grammes of ammonium molybdate c. p. in 300 c. c. of ammonium sp. 0.96, filter, and add 675 c. c. of nitric acid sp. 1.20. Allow to stand, and decant from any sediment.

† To prepare ammonium nitrate solution, dissolve 100 grammes of ammonium nitrate in 1,000 c. c. and add 25 c. c. of nitric acid.

‡ To prepare magnesia mixture, dissolve 55 grammes of magnesium chloride in 350 c. c. of ammonia of sp. 0.96, add 140 grammes of ammonium chloride and enough water to make one liter; filter from any sediment.

§ To prepare ammonium citrate solution, mix 370 grammes of commercial citric acid with 1,500 c. c. of water; nearly neutralize with solid ammonium carbonate. Boil to expel the carbonic acid. When cold, add ammonia until exactly neutral, testing with delicate litmus, and dilute to 2,000 c. c. The gravity should be 1.06.

LONGLEAT.—AN ENGLISH COUNTRY RESIDENCE.

THIS beautiful place, the seat of the Marquis of Bath, is situated on the confines of Wiltshire and Somerset. A considerable portion of the grounds are within the latter county, while the house stands in Wiltshire. The principal entrance lies southward, from which direction the road leads through the pretty village of Horningsham, after leaving which it enters the park, where there is a lodge about a mile distant from the mansion, to which from this point the drive is in a straight line through an avenue of majestic old elms, part of which in different places a long time ago were unhappily removed; more recently these gaps have been filled up with young trees that are thriving satisfactorily, but, needless to say, the requisite uniformity of growth and size so essential in the trees composing an avenue is wanting. Avenues sometimes exist where their absence would have been preferable, either through their being out of keeping with the surroundings or by mistakes in the planting; but here the avenue is not only quite in character with the place, but the judgment has been correct in allowing enough greensward between the road and the trees, proportionate to the extent and importance of the place. It would be interesting to know when and by whom Longleat avenue was originally planted. Be this as it may, this old avenue forms a fitting approach to the palatial mansion to which it leads. A sight of the building as it is approached conveys the idea that whoever chose the site had an eye to the comfort a sheltered position affords, to which none appear to have been more alive than the religious communities of old, who seldom made any mistake in the positions which they

son of the Marquis of Bath. These were brought to a close by a day of amusements in the park, with a luncheon of which over 1,100 friends of the family and tenants on the estate partook. In the evening huge bonfires on the hills in the surrounding neighborhood and fireworks in the grounds brought to a conclusion a series of festivities on a scale such as is seldom carried out.

The grounds are in keeping with the style and extent of the mansion. The whole extent inclosed is some 16 miles round; this includes about 5,000 acres of woods, which mostly occupy the high surrounding land more especially on the eastern side. Within the grounds there are 16 miles of private roads. The great extent of surface occupied by the woods might lead any one who has not seen the place to suppose that there was a deficiency of open space, but this is far from being so—long, broad, irregular expanses of grass meet the eye at every turn, the groves and groups of fine old trees that have reached maturity, and also those of less age, have been well placed with a view to effect. As might be expected in an old place of this character, elm, oak, ash, beech, lime, and sweet chestnut predominate in the positions of most importance, and from the proportions they attain evidently like the soil; but most of the hardy deciduous as well as evergreen trees do well.

One of the features of the place are the extensive sheets of water, five in number, succeeding each other in irregular line; these have been formed by damming at intervals the stream which follows the course of the valley from south to north on the eastern side at some distance from the mansion; the largest of these—that which is opposite the building—is some half a mile in length. On this side, the lawn, which occupies the intervening space between the house and the water, de-

direction; here, associated with deciduous kinds of trees, are numbers of the best conifers, that have attained a goodly size. Among these may be named *Cupressus macrocarpa*, nearly 50 feet high; *Taxodium sempervirens*, 60 feet high; *T. distichum*, over 60 feet; *Abies menziesii*, 60 feet; *Salisburia adiantifolia*, 65 feet; *Dacrydium franklini*, 30 feet. In the high woods adjoining, westward, there are numbers of silver firs that run from 115 to 125 feet high, magnificent trees with massive trunks and still in a thriving condition. In many parts of the grounds there are trees of unusual size, noticeable among which are *Liriodendron tulipiferum* (the tulip tree), the largest of which are nearly 100 feet in height; oak, girthing 24 feet at 4 feet from the ground; elm, 120 feet high, girth 26 feet at 4 feet from the ground; and many others only a little less than those named are in a healthy, thriving state, and to all appearance are likely to keep on growing for an indefinite time.

The natural formation of the land, with its undulating surface, has done no little in making the work of the planter so successful here; this is not alone perceptible in the grounds in immediate proximity to the dwelling, but also in the more outlying parts, which are equally deserving of notice. Especially is this so in the eastward direction, which is reached by the road that leads from the entrance lodge already mentioned, through the village of Horningsham, which, by the way, demands a few words. It is somewhat extensive, the houses being picturesquely scattered on each side of the road for about a mile. Some of the roofs are thatched. The whole presents a neat appearance, such as is rarely met with. This in no little degree is owing to the way that they are covered with climbing plants, consisting of ivy, *Escallonia macrantha*, *cotoneasters*,



LONGLEAT, THE SEAT OF THE MARQUIS OF BATH.

selected for their habitations. Seen from the different roads by which it is reached, the house has the appearance of standing in a land-locked valley, yet the space immediately surrounding it is sufficient in extent, before the ascent in each direction begins, to prevent a feeling of too much confinement. A priory of Augustinians, founded about 1270, occupied the spot where the mansion now stands; after an existence of some 250 years it was dissolved, and in 1540 was bought by Sir John Thynne.

From an interesting account of Longleat by the Rev. J. E. Jackson, rector of Leigh Delamere, it appears that the present building was begun by Sir John Thynne in 1568; operations were continued for about ten years; he died in 1580, at which time it would seem most of the external work was completed, but only part of the interior, which was finished by his successors. It is a noble structure, partaking mostly of the Italian style, as will be seen by the accompanying illustration, and is in excellent preservation, having well withstood the long wear of the 300 years that have elapsed since its substantial walls were raised. The dimensions are 230 feet long by 180 deep—a large building, but by no means too large to accommodate the numbers that on several occasions have been gathered under its roof. Soon after it was built, Queen Elizabeth visited the place; Charles II. was there—each, no doubt, following the fashion of the times, would have a host of retainers. George III., accompanied by several of his family, came to Longleat in 1789, at which time it is said that 135 people slept there; on the two days of his stay, an extraordinary amount of feasting went on. In 1881 the Prince and Princess of Wales and suite spent the greater part of a week here, during which a ball was given in the great hall, at which 600 guests assembled. In 1883 there were three weeks' rejoicings at Longleat to commemorate the coming of age of Viscount Weymouth, eldest

seeds considerably; there is here a large flower garden very effectively planted with the usual kinds of summer bedding plants; in addition to this there are a number of large beds dispersed over this part of the grounds similarly filled, which, combined with the flower garden, have a gay appearance. By the side of a long walk running northward from the east front of the house there is a border bright with blooming plants.

On the north front there is a space of grass interspersed with shrubs, and beyond this a large garden arranged in the old Dutch fashion, filled with evergreens in rows, consisting principally of yew, box, *Berberis darwinii*, holly, *cotoneaster*, and the like, with narrow grave paths between and grass verges. The shrubs are kept closely clipped to about a foot in height, and the whole is as angular and formal as this terribly unnatural style of gardening demands. At all events, it serves as a living illustration of the fashion prevalent two hundred years ago, about which time this garden seems to have been made. Northward from this stands the orangery, now principally filled with camellias. Near here is a lawn-tennis ground; the spot for this is well chosen, as here there is an absence of the dissight that a dead level space in a conspicuous position on a lawn often produces. Farther in this direction a wall follows the side of the water, wherein is an island occupied by tall trees, in which a colony of herons build. Retraversing this walk, one cannot fail to notice the beauty of the rising slope on the opposite side of the water, stretching for a long distance past the mansion, with its broad expanse of grass relieved here and there by groups of trees, and backed by the dense woods that clothe the summit of the ridge, giving shelter from the eastern blast—an essential that it behooves the planter not to lose sight of.

To the right of the entrance front of the building, at a short distance away, a walk commences that leads through the pleasure grounds, which run in a southern

roses, *elematis*, honeysuckle, and the like, which clothe the walls so as scarcely to leave a bit visible. The uniformly beautiful condition these present is in no little owing to the interest which the Marquis takes in their appearance, and who provides the labor to keep the plants in order.

After passing the village, the road bears to the left northward, traversing the wooded ridge in the direction of Warminster. The trees are not, as usually seem, in an unbroken line flanking the road, but in many places are sufficiently far away to leave room for flowering plants such as *Cotoneaster simonsii*, *Deutzia crenata*, *Spiraea* of sorts, and similar things planted in masses, each kind separately, with masses of red dogwood and pampas grass introduced among them. At some distance in this direction there is one of the many divergent roads that lead to the various points of interest within the grounds; that to the west from this point leads to Heaven's Gate, where the finest view of the place, as well as the country westward, presents itself. Here, from an open space in the wood, high up as from the vantage point of an amphitheater, the panorama of Longleat at once breaks on the eye, while in the far distance may be seen the tower on the Mendip Hill and Amerdown Park, the seat of Lord Hylton.

Returning to the Warminster Road, the road is flanked right and left by dense masses of rhododendrons and other flowering shrubs, with quantities of the best kinds of conifers, young trees, growing freely. Again, reaching the main road, there is another that leads from it at right angles to Sherwater. Here the descent is rapid, through immense breadths of old woods on each side, principally oak and beech.

Further on, entering the valley, which here runs eastward, the character of the planting is quite different: broad stretches of silver firs and old Scotch firs occupy the higher portions of the slopes, while quantities of the newer kinds of conifers are on the lower

ground. These consist of *Cedrus deodara*, *Cryptomeria japonica*, *Thuopsis borealis*, *Wellingtonias*, etc. These are growing like willows in the bottom of the valley, where soil and shelter alike suit them. Still further in this direction is Sherwater, a piece of water some forty acres in extent, which has been formed by constructing a dam across the valley, through which runs a stream, the water of which is thus held. It is a favorite place with tourists, who, by permission, are allowed the use of the boats kept on this miniature lake. Near at hand is the village of Crookerton, passing through which and turning to the left the way leads back westward through an extensive tract of woodland, until it again joins the Warminster Road, where, some distance further northward, there is another entrance to the park at about $2\frac{1}{2}$ miles from the house. Entering at this point, the road in places has a steep descent. Here again the views that keep on continually presenting themselves are alike beautiful and varied; wide open glades stretch out in different directions, with fine trees grouped in masses, such as their respective positions happen to require; the road thus continues until it reaches the mansion. Another road from Frome, which is some half dozen miles distant, enters the park on the western side, and continues until it joins the others near the house.

THE FRUIT HOUSES.

Few places can boast of such grapes as are now grown at Longleat. The principal range of vineries is span-

crop of which had been cleared some time. The adjoining house was filled with melons; this, like the rest of the range, is about 40 feet long, yet three plants occupied the house. Mr. Pratt gives all his melons much more room than many growers think necessary; each plant is in a brick pit, from 3 to 4 feet square; in this way they keep on bearing all through the season. When I saw them, about the middle of August, they were carrying a beautiful lot of fruit. The sort principally grown is one of Mr. Pratt's raising, and bears the name of Longleat Perfection; it is a cross between Eastnor Castle and Meredith's Hybrid Cashmere, and is a fine kind in every way, a free bearer, the fruit good-looking and highly flavored. After these comes the second peach-house. Another house is devoted to figs.

Several houses are filled with flowering and fine-leaved plants, the latter consisting of large quantities of *Caladium argyrites*, *dracenas*, *crotons*, *pandanus*, palms, ferns, and the like, mostly small stock, best suited for hall and table decoration. One house, 60 feet long, is occupied by gardenias, planted out, and *Eucharis amazonica*, of which there is a fine stock of strong, vigorous plants.

The useful *Dendrobium nobile* is grown in quantity, and so are the red and the yellow eyed varieties of *Calanthe vestita* and *C. veitchii*. These *Calanthes*, with the *Dendrobiums* to follow, give through the late autumn and winter a succession of flowers, than which there are few more beautiful or generally useful, their

THE NEW NATIONAL MUSEUM AT AMSTERDAM.

A SHORT time ago, the new National Museum at Amsterdam was opened to the public, after having been in the course of construction for the last seven years. The building was designed by and executed under the supervision of Mr. P. G. H. Cuypers. The style is the Netherlands Renaissance. Great care has been taken with even the most minute details, and thus the architect has been able to construct an exceptionally handsome building, having a ground floor of 35,000 square yards, for a comparatively small sum.

For our engraving we are indebted to the *Illustrirte Zeitung*.

THE BEST KIND OF DRUMMER.

AN advertisement in a trade paper representing your line of business.

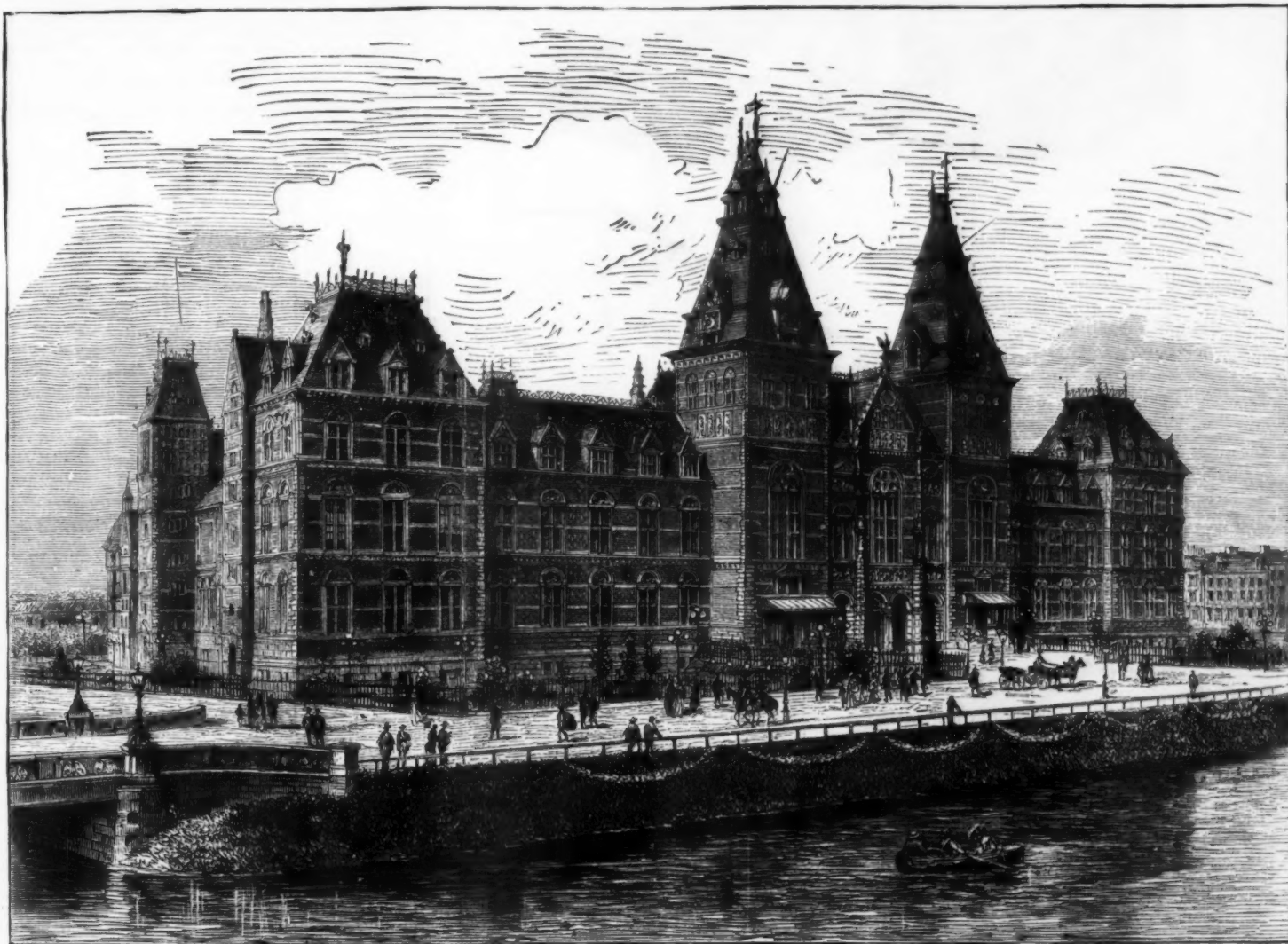
It has most of the merits and none of the vices of the "traveling man," besides many advantages that are entirely its own.

It travels in all directions at once.

It visits your customers every week.

It interests them in your town, and is building up the general prosperity while it is faithfully transacting your particular business.

It talks with thousands of tongues, and has the confidence of its hearers.



THE NEW NATIONAL MUSEUM AT AMSTERDAM.

roofed, in three divisions; the first of these, commencing at the northern end, is between 50 and 60 feet long, by 30 ft. wide; it is filled with Black Hamburgs, carried this season an immense crop of fruit, beautifully finished, the bunches collectively very much larger than usually borne by vines of their age. (They, like those in the two other compartments, have been planted sixteen years.) Many of the bunches would run from six to seven lb. The central portion, nearly ninety feet long, contains four Muscats; each vine here, as in the rest of the range, occupying much more space than is generally given, were also bearing a magnificent crop fast coming to maturity, and promising to color well. The bunches were very large; not a few would reach half a dozen pounds each. The remaining division was filled with five vines, two Black Alicante, two Lady Downe's, and one Mrs. Pince; the crop they were carrying was similar to that in the first and second divisions, and quite equal to them for the size and beautiful finish of the fruit. The bunches of Lady Downe's were larger than one often meets with, and so even as to show that there had been an absence of scalding, to which this favorite late variety is so liable. The Alicante were as large and handsome in the bunch as this handsome grape is when well managed; while the crop of Mrs. Pince was unusually well finished, the berries large, black, and even. Mr. Pratt may be complimented on having in this range a crop of grapes such as is not often seen.

In a range of old-fashioned hip-roofed houses, in several divisions, the first is filled with peaches, the earliest forced. Next to this is the earliest vinery, the

endurance in a cut state being not the least merit they possess.

The walls are extensive, and covered with the usual kinds of fruit trees; pears especially were carrying good crops. In the principal division of the kitchen garden there is a very useful contrivance for preserving bush fruits from the birds. A border against a north wall, some 80 yards long and 4 wide, is planted with currants and gooseberries; the former are standards, there are three rows of them, and three of gooseberries, mostly Red Warrington; on the wall are Morello cherries. The whole is inclosed with a wooden framework consisting of light rafters resting on posts about 4 feet high in front, and on the wall at back; over this strong galvanized iron wire netting, about $\frac{1}{2}$ inch mesh, is permanently fixed, with doors and ends of the same material. In this way a very large quantity of fruit is secured without the trouble entailed by the use of the ordinary twine nets, which, to cover a space such as this, would give a considerable amount of labor annually, and which, in addition to the wear and tear of nets, would no doubt in the end be more expensive than a durable wire inclosure.

The kitchen garden is about 9 acres in extent. Hardy fruit and vegetables, like the several other departments of gardening, are well managed, collectively giving evidence of the skill and attention brought to bear on their cultivation.—*T. B. in the Gardeners' Chronicle*.

FROZEN oranges are regarded as the cause of some recent sickness at Palatka, Fla. The poison in the peel is driven into the orange by the frost.

It doesn't get drunk.

It doesn't play faro.

It doesn't bring in any supplementary fancy bill of "expenses."

It requires no "commissions."

It doesn't swell 'round on the credit and name of your house.

It never gets mad and threatens to transfer its good will to a competitor in business or a rival town.

It never sets up in business for itself on the credit it has built up at your expense or has artfully filched from you.

It doesn't add so much to your general expenses as to reduce to zero the margin you would like to offer good customers.

It doesn't cost you many thousands of dollars a year—at most, only a very few hundreds.

It brings your customers to you, and makes them your personal friends.—*Journal of Progress*.

SOMETHING of a novelty in clocks is a recently patented arrangement by which the metrical striking announces the hour without the necessity of counting the strokes. This is effected by applying the Morse system of intervals to the stroke of an ordinary clock. The ear at once detects the correct hour, even if the first strokes were not heard or counted. There will be little difficulty in learning the new system, and those who prefer can still count the strokes. The mechanism is stated to be inexpensive, and applicable to existing clocks.

EVANS' COMBINATION IMPLEMENT.

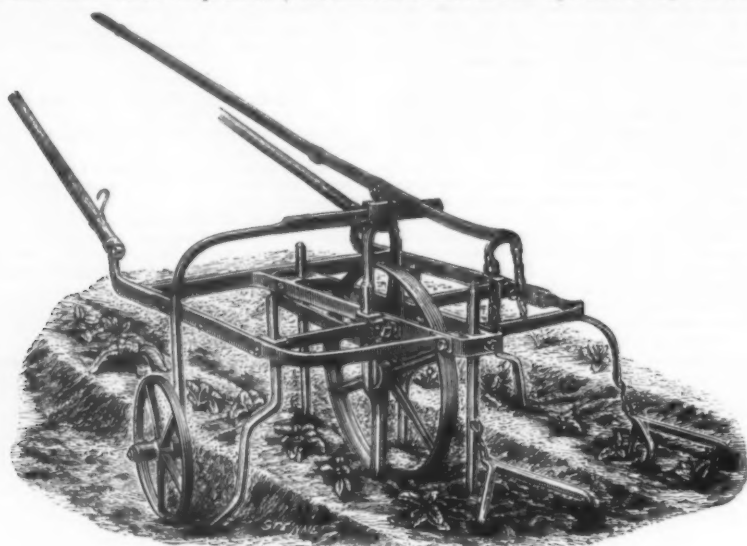
At the recent Royal Agricultural Society Show at Preston a very ingenious combination agricultural implement was exhibited by T. W. A. Evans, of Kidwelly, South Wales. This implement is worked by one horse, and can be used, with some slight adjustment, for several purposes. As a ridge plow it can be set to any depth and width, and the furrows are kept uniform by the roller in front, while one of the side wheels acts as a marker for the next furrow. If preferred, the man

puts all out of gear, enabling it to be easily turned at the headlands or taken from one place to another. The man walks by the side of the horse, which gives him greater command in guiding, and the machine requires a very moderate amount of labor to draw it. Another advantage is that in the winter the shafts can be unscrewed from the frame and put by with the lever. The frame (about a yard square) stands up on end. The small turnip rollers are tied to the large roller frame, and everything else belonging to it packs away in a box 3 ft. 6 in. by 2 ft. 6 in. by 1 ft. 6 in., so there is

without any obstacle throwing it back against the side of the ship.

In the Suez Canal, then, there is more chance of a vessel taking a lurch, and, consequently, of stranding. Doubtless such accidents are usually not serious, and do no particular damage to the ship's hull; yet they stop her, and cause her, as well as those in her wake and those coming in the opposite direction, to lose time. This alone is a sufficient reason for seeking a means of preventing the rolling of vessels in such situations. For this there is no other remedy than to make the rudder as sensitive as possible. By this means the vessel can be brought back to her course on the least show of deviation from it, and be kept in the axis of the canal.

In consequence of the lateral pressure exerted by the water displaced, and of the reduction of speed, such sensitiveness is much less in the Suez Canal, as in large navigable rivers, than on the open sea. This may be compensated for (1) by increasing the ship's stability, (2) by maneuvering the rudder more rapidly, or (3) by increasing the submerged surface of the rudder, and consequently its action. The first condition may be realized by so distributing the weight of the ship that the stern shall sink deeper than the stem. If such condition be not observed, if the ship be on an even keel, she loses her stability, tends to go out of her course, and it is difficult to hold her to it. This has happened in the case of many ships traversing the Suez Canal. It would be well, then, to pay more attention to giving such stability to ships, either when they are being constructed, or especially when they are being loaded. When special pilot charges existed, based upon the submergence of the ship, there was a certain profit to shippers in so distributing the weight as to diminish the draft astern. Now that such charges have ceased to exist, there is no longer any reason for not giving ships the above-named condition of stability. If the vessel be on an even keel, the difficulty may be remedied



COMBINATION AGRICULTURAL IMPLEMENT.

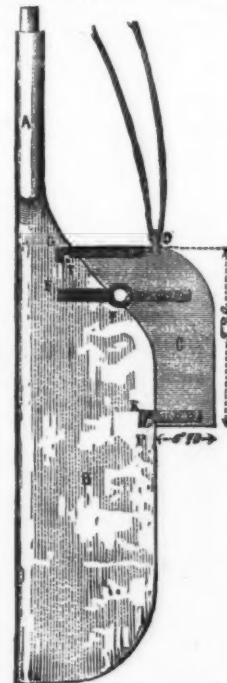
can walk by the side of the horse, and the lever can be turned in front, as in horse hoes. By changing the mould-board's roller, and taking off one wheel, other knives are attached to the frame, converting the implement into a horse hoe, when it will work one row and two half rows at the same time. The knives can be regulated to any depth or width required, and are so made that they do not damage the foliage of the plants; it can, therefore, be used to hoe cabbages without injuring them. Two light harrows follow to turn over the weeds, and the lever is worked from the front. By taking off the turnip knives and fixing two pronged irons on the frame, the implement is converted into a potato digger, which raises two rows at the same time, without injuring the potatoes. By removing the inner frame and wheels it can be fitted as a drill for mangolds, turnips, etc., doing two rows at once. The seed boxes can be emptied in less than a minute if required. In either form of using the machine, one lever

shows the implement adapted to the various purposes described.—*Engineering*.

SUPPLEMENTARY RUDDER FOR USE ON THE SUEZ CANAL.

SHIPS that traverse the Suez Canal find navigation very different from what it is upon the open sea. To go some few degrees out of their course, and to take more or less time to return to it, are matters of no serious consequence on a, so to speak, boundless extent of water. But it is not the same on a canal, where, in consequence of the proximity of the banks, a lurch, even a slight one, may cause them to strand.

The currents and reactions due to displacement are much stronger in a confined space, as in a canal, than upon the open sea, where a wave may become spent



DECERFZ'S SUPPLEMENTARY RUDDER.

by increasing the rudder's power of action. This is what is done on river boats, which, on account of the slight depth of the channel, it would, from a commercial point of view, be too disadvantageous to give a deeper draft aft than fore. Such power of action of the rudder is dependent, in the first place, on the rapidity with which the latter can be moved. This condition is properly observed on the majority of ships which make the transit of the Suez Canal, and nearly all of which can be steered from the captain's bridge. Those vessels whose rudder is actuated by steam are unquestionably superior in this respect, and it would be desirable to see this improvement applied in a general way to ships that have to make the transit of the canal. As for the width of the rudder cheek, it must be admitted that this is too often insufficient. White says that the width, as a rule, should vary between one-fortieth and one-sixtieth the length of the ship. Scott Russell, modifying this rule, fixes the width at one-fiftieth of the length, plus one foot. For a 300 foot ship, (a now frequent type) it would require, then, according to Russell's rule, a rudder seven feet wide. This is a width greater than that usually adopted. So to this insufficiency of the rudder's width we must look for the cause of vessels being stranded in the canal.

Although, through the experience acquired, and the improvements in the state of the canal that are being constantly introduced, fewer and fewer vessels are running aground, it is well to endeavor to still further diminish the number, and we have just seen that one of the most efficient means would be to increase the surface of the rudder during the transit of the isthmus.

Captain Decerfz, one of the officers of the company at Port Said, has found a simple means of effecting this through a supplementary rudder, which we shall describe, and which is rendering the most useful service. Satisfied with having contributed to facilitating navigation in the canal, Captain Decerfz has taken no thought of deriving personal profit from his idea, but has abandoned it to navigation, and, since 1876, this rudder of his has been adopted by the English Postal and the Peninsular and Oriental companies.

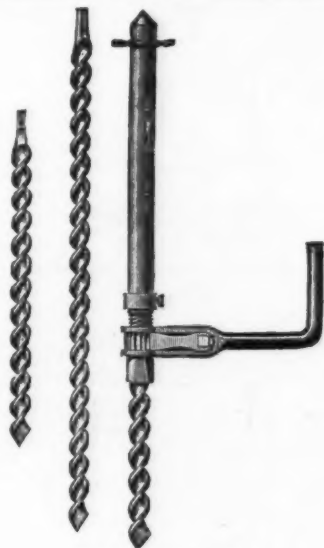
This apparatus (see figure) may be constructed of, say, one-half inch iron plate, shaped to correspond to the bend of the rudder cheek, and having a length of but 7½ feet, and a width of 27½ inches at its lower part. To this plate is fixed a forked piece, F. The center of

this latter, as well as the plate, contains a threaded aperture, V, into which passes a binding screw that secures a connection with the rudder. A ring, D, serves to suspend the apparatus at the moment it is being put in place, and when it is being removed. When the apparatus is being adjusted, two hooks, G K, fixed to the plate, come into contact with two round iron tenons, T P, that were fixed to the rudder when the ship was in dock. The placing of these tenons is the only precaution to be taken in advance. The adjusting is effected by suspending the supplementary rudder by the ring, D, and then letting it down gently so that the fork shall embrace the rudder and the hooks engage with the tenons. The supplementary rudder is then in place, and is fixed by inserting the screw, V, the pitch of which should be somewhat wide, and the head of which should be large enough to allow a man standing in a rowboat, and provided with a long-handled key, to screw it home. This operation requires but a few minutes, and the final removal takes no longer. The entire apparatus weighs but 154 lb., and it does not cost over twenty dollars.

If, instead of a simple sheet of iron plate, which usually suffices, its consists of two cheeks connected by riveted cross-pieces, its strength will be increased, but it will cost a little more. In any event, it gives the rudder such sensitiveness that ships provided with it keep in the axis of the canal without trouble. It is to be desired, in the interest of universal navigation, that ships that make the transit of the Suez Canal generally adopt an apparatus which is so easily used and costs so little, and which renders it almost certain that they can effect their passage without any danger of coming into contact with the banks.—*Le Genie Civil*.

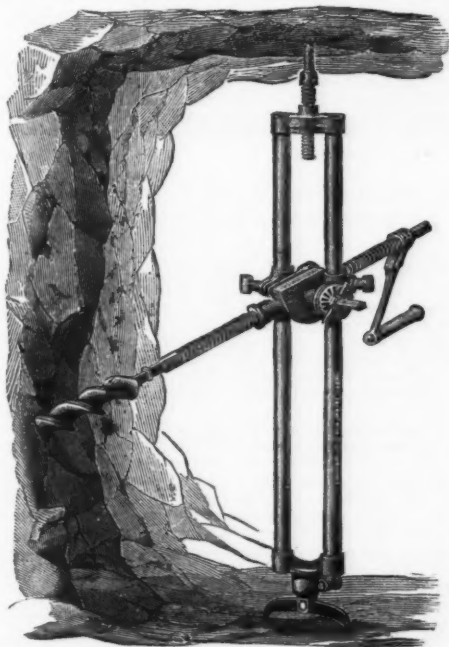
COAL-BORING MACHINES.

We illustrate to-day some marvels in rock and coal-boring machines, which are manufactured by the



THE "RATCHET."

Hardy Patent Pick Company, Sheffield. The firm has during the past two years made great improvements in the many appliances for mining operations, among them being the hand-boring machines, of which they make various types to suit any class of work. Heretofore the machines in use have been of a very heavy and costly type, but this firm—who may doubtless claim to be the foremost in the manufacture of mining



THE "UNIVERSAL"

tools—have succeeded in putting into the market machines which are capable of doing the same work, and, at the same time, so light and portable that a lad can carry them through the workings of the pits, and the price has been brought within the range of workmen.

The "Ratchet," as will be obvious from the illustration, is a thoroughly substantial machine, capable of

penetrating the hardest stone that can be bored by a rotary drill. Its construction is of the simplest, and it is operated by simply placing it in position between a plank or pit prop and the face of the rock, and it is ready for work. The company have recently patented an improved automatic feed which is applied to this machine. This regulates the propelling speed of the screw, and allows the drill to feed forward just as fast as the material is cut, and no faster, thereby obviating all chance of breakage.

The "Little Tiger" is of lighter construction, and is essentially for boring in coal. At the same time, all the parts being made of steel, it is immensely strong, and capable of doing much of the work that has previously been done by the heavier machines. This is made with a double standard, and where the space between roof and floor is deep, it is made telescopic, which enables its being worked in almost any space. This machine is capable of penetrating coal just as rapidly as the handle can be turned. This little machine is truly the miner's friend, and the price complete with three drills being about 35s., he is not slow to profit by its use.

Another machine is the "boss" which consists of a single boss or screw nut, with a claw cast on each corner. A screw thread is cut through the entire length of the boss in order to receive a propelling screw. These, together with the handle and drills, constitute the entire apparatus. To put the drill to work, all that is necessary is to fasten a prop or plank between the roof and floor of the cutting, and bore a hole through it sufficiently large to allow the propelling screw to pass through. On placing the boss on the side of the plank next to the face that is to be bored; and setting the drill in position, a few turns of the handle cause the claws to fasten themselves in the wood, and so secure the boss. In this way coal or soft stone can be penetrated as rapidly as the handle can be turned.



THE "LITTLE TIGER."

The "Acme," which we also illustrate, is another coal-boring machine, of rather more elaborate construction, which can be worked at any angle. It is set on a single hollow standard, and though light is very strong and capable of ready adjustment, being provided with a peculiar clip, by which the workman can turn the drill in any direction without having to move the standard. With this apparatus, boring can be carried on very close to the roof.



THE "ACME."

Another machine is the "Universal" perforator, invented by Messrs. Wainwright and Stayner, which is also illustrated above. This is a powerful apparatus, mounted on a double standard, and specially designed for tunneling in mines. All the mechanism is well under cover. The screw-box works on roller bearings, so that friction is reduced to a minimum, and by a

novel arrangement of friction disk the feed can be regulated with the greatest nicety. Another novel feature is a compound clip and claw, whereby the machine when at work is held perfectly rigid, while, as is often desirable, it can be turned in any direction without changing the setting. Lengthening rods are supplied, when required, for long borings. We understand that all parts of the various machines manufactured by the Hardy Patent Pick Company are made to standard gauges, and are usually kept in stock, so that in case of accident or breakage, parts for repairs can be immediately supplied.—*Colliery Guardian*.

SIBLEY COLLEGE LECTURES.—No. 2.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

By J. C. HOADLEY, of Boston, Mass.

"FIRE."

FIRE, considered as the practical source of all useful artificial heat, is the phenomenon attending the rapid union of one or more of a very few elementary substances found in nature with the oxygen of the air. All substances, with a few exceptions—gold being a notable exception—unite with oxygen at all ordinary temperatures, but unless the union takes place rapidly, the heat generated is dispersed as fast as it is produced, and the result is not fire, or combustion, but oxidation; but if the heat produced by mere oxidation be intercepted and suffered to accumulate, a high temperature is sometimes reached, resulting in fire, at last. This process is called spontaneous combustion. Of useful combustible substances, there are only two—carbon and hydrogen; for sulphur, although highly combustible, is unimportant. Carbon, solid at all ordinary temperatures, can be volatilized only at very high temperatures, or at lower but still high temperatures, by the aid of chemical affinity. The products of its combustion, either completely, to carbon dioxide, or partially, to carbon monoxide, are gaseous; and it follows that, in burning, carbon must pass through a change of state, from a solid to a gas, a circumstance of much importance.

Carbon exists in three forms, differing extremely in most of their sensible qualities, although (save for accidental impurities) identical in substance—coal, graphite, and diamond. With the first of these alone we have to do; but coal presents various degrees of compactness or solidity, as in wood charcoal, coke, anthracite, and gas-retort charcoal, and the differences in this respect are not without influence on the available heat-producing power of the coal.

Hydrogen, unlike carbon, is a gas, and the lightest substance known. No free hydrogen exists in nature, and the vast stores of it locked up in all the waters of the seas, the earth, and the air, are unavailable as fuel, being firmly united with eight times its own weight of oxygen, as the result of accomplished combustion.

Very great quantities of available hydrogen fuel exist, however, in combination with carbon in the multitudinous forms of the hydrocarbons, in bituminous coal, in petroleum, and in natural gas—combinations more or less stable, requiring an unknown quantity of heat energy to set them free to enter into new combinations with oxygen; but in all cases more easily separated than are the component gases of water—oxygen and hydrogen. Carbon is the more important fuel of the two, and therefore the most important fire-sustaining element in nature.

Of carbon, too, stores almost inconceivably vast exist in an unavailable condition disseminated in slates, shales, and carboniferous limestones, too much diffused for use as fuel.

That these two all-important elements exist at all free from combination is due to the power of the sun's rays, acting upon the leaves of plants, to decompose carbon dioxide and water, setting free the imprisoned oxygen in each case, and causing the divorced carbon and hydrogen to enter in new combinations into the woody fiber of vegetable forms. Hence all our supplies of living, ever-renewed fuel upon the earth's surface, and the vaster, yet finite and diminishing, stores of coal, petroleum, and hydrocarbon gases in its depths.

The combustion of hydrogen is a simple affair. A gas already, it unites with eight times its own weight of oxygen to form nine times its own weight of water—a liquid; but as liberated by combustion, a temporary gas, in the form of steam. The hydrogen, it is probable, ever escapes unburned on any ordinary fire. As a result of the great condensation, the heat produced is very great, no less than 68,002 British thermal units—more than 4½ times as much as from the burning of an equal weight of carbon; and after deducting the heat carried off by the vaporization of the resulting water, more than 3½ times as much.

The combustion of carbon is far from simple. A solid is first to be converted into a gas, and then united with 2½ times its own weight of oxygen to form 3½ times its own weight of gaseous carbon dioxide (CO₂), equal in volume to the uniting oxygen alone, and therefore under very great condensation, considering the carbon at the instant of union as gaseous.

Carbon dioxide at a temperature above 1,000° Fah., in passing through layers of coal below that temperature, dissolves carbon, taking up an additional molecule for each two molecules of oxygen already united with one carbon molecule, the resulting proportions becoming molecule for molecule of each element; and, by weight, 1½ times as much oxygen as carbon. The result is the disappearance of a very large part of the heat produced by the original burning of each pound of carbon to CO₂ = 14,544 B. t. u.

Heat absorbed in the process, 10,008 B. t. u.

Residual heat after forming CO, 4,451 B. t. u.

Two pounds of carbon have disappeared in gas (CO), and only 30.6 per cent. as much heat has been produced as would have been produced by the burning of one pound of carbon to CO₂.

It may make the matter plainer to imagine the process reversed, that is, the carbon first volatilized to the combustible gas, CO—2 molecules of carbon to 2 of oxygen; 2 pounds of carbon to 5½ pounds of oxygen.

The gasification of 2 pounds of carbon will absorb 5,642 × 2 = 11,284 B. t. u.

The sensible heat produced will be equal to 4,451 × 2 = 8,902 B. t. u.

If now the CO be burned to CO_2 , the sensible heat produced will be equal to $10,093 \times 2 = 20,186$ B. t. u.

Total, 40,372 B. t. u.
But the quantity of heat absorbed in the gasification of the 3 pounds of carbon has disappeared as heat by its conversion into molecular work; and this is $5,642 \times 2 = 11,284$ B. t. u.

Net for 3 pounds of carbon, 20,088 B. t. u.
And for 1 pound of carbon burned to CO_2 , 14,544 B. t. u.

The loss of heat attending the formation and release to the air of CO, about 70 per cent., is serious; but the residuary heat is subject to all the absolute losses at the chimney, by radiation and otherwise, and not more than one-sixth to one-fifth of the full heating power of the carbon is available.

Fortunately, this danger is not as great as it appears. Carbon monoxide can be formed very readily, and its formation can be as readily avoided. It has been demonstrated that only minute traces need ever be formed in any reasonably well-managed boiler furnace, while dampers are open and the fires are burning freely. While the fires are banked, the proportion of carbon burned to CO is large, although the actual quantity is relatively small. Bituminous coal suffers less loss from this cause than anthracite; on which account it is advantageous to use bituminous coal for banking anthracite fires. A crust is formed, beneath which the escaping CO is conducted to orifices through which it issues to burn like ordinary jets of gas. But dampers should be made to shut as tight as possible.

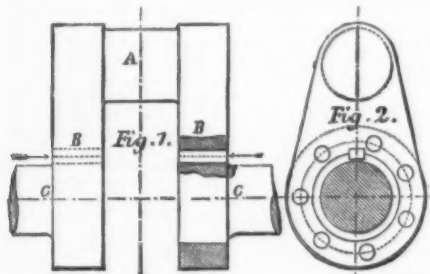
Combustion cannot be carried on with less than 20 pounds of atmospheric air for each pound of anthracite, and something more for bituminous coal, which usually has as much carbon as anthracite has, and 3 or 4 per cent. of hydrogen in addition. The time allowed for combustion, only 3 or 4 seconds, even with externally fired boilers, is too short to permit a more complete absorption of the oxygen than about one-half of that which entered through the grates and through the fire. No air should enter in any other way, and great care should be taken to prevent all leakage through brickwork and around doors and arch fronts.

The two things about a fire most important to be known are, *first*, the temperature of the escaping gases, and *second*, their composition, which, taken in connection with the weight and analysis of the coal burned, will give the quantity of the gases. No details of the process of analyzing the gases can be given here. The volumetric method, by the use of the Winkler apparatus, is easy and expeditious, and (in skillful hands) reasonably accurate. The gravimetric method, conducted by an expert chemist, gives the weight of coal burned as accurately as it can be weighed at the furnace door. Care must be taken to procure fair samples for analysis, as heterogeneous mixtures of gases exist at the same instant in boiler flues and chimneys.

REPAIRING BROKEN CRANK-SHAFTS.

OUR illustration represents a novel and very effective method of repairing broken crank-shafts, invented by Mr. Henry Foster, Newburn Steel Works, Newcastle-on-Tyne.

It is well known, says *Engineering*, that the break-



ages of crank-shafts almost invariably occur at the angle formed by the junction of the crank-pin and crank-web, where the forging is most likely to be defective, and where the change of form of the shaft throws great local stresses on the material.

These breakages are evidently produced more by bending than by twisting strains, and on the slightest indication of fracture at the points mentioned, the shaft, although perfect in all other respects, has hitherto been condemned as useless, and another entirely new shaft substituted, involving considerable outlay, only to be repeated on another indication of flaw.

In the method which we illustrate, instead of throwing away the whole shaft, the fractured pin and webs are turned off, leaving a small boss at each end of the two parts of the shaft; upon these bosses there is fixed another crank-pin, A, together with its two crank-webs, B B, formed in one piece. The new cranks are shrunk on to the lengths of shaft forming the body of the crankshaft, and afterward further secured by means of keys. The end of each length of shaft, C C, at its junction with the crank-web, is left somewhat larger in diameter than the other part of the shaft, so as to enable the keys which secure the crank-webs to the body of the shaft to be driven in from the outside of the crank-webs in the direction of the arrows. A broken crankshaft after being thus repaired is now working and giving perfect satisfaction where three new crank-shafts had previously broken.

The invention is not confined solely to the repairing of crank-shafts, but is applicable also to the manufacture of new crank-shafts, which, when thus made, are essentially built shafts without the disadvantage of having a large amount of unbalanced material at the crank-pin end of the webs. The crank-pin with its two webs in one piece is preferably made in one casting of special mild steel, while the other parts of the shaft are forged.

The Board of Trade have decided to approve of this shaft, "on condition that a surveyor of the Board of Trade should witness the testing of the pieces which are required to be cut from each shaft and each web and pin, for tensile strength, elongation, and bending, in accordance with the usual practice, and the results of the tests be submitted to the Board for approval";

and Lloyd's Committee have decided to approve of this shaft, "provided test-pieces cast on it be proved to have a tensile strength not exceeding 30 tons per square inch, and pieces $1\frac{1}{4}$ in. square permit of being bent cold through an angle of 90 deg. over a radius not exceeding $1\frac{1}{4}$ in., and the shaft when machined be found to be perfectly free from blow-holes, and in other respects to the satisfaction of the local engineer surveyor."

These conditions of test can be readily fulfilled by the material of which these crank-shafts are made.

THE WENHAM LIGHT.

AN interesting new lamp for the economical consumption of common gas has been invented by Mr. F. H. Wenham, C.E., and is in course of manufacture by the Wenham Patent Gas Lamp Company, and was shown in action at the Inventions Exhibition. The claims made by the company as to the economical advantages

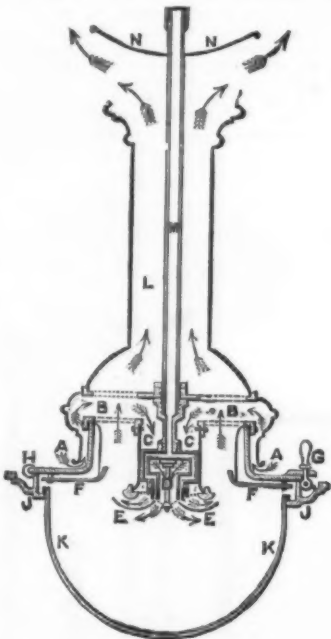


FIG. 1.

of the lamp are, says *The Engineer*, exceedingly large, namely, that it increases the illuminating power of common gas from 200 to 400 per cent., and that, too, without charging the gas with additional hydrocarbons. In the Wenham lamp the gas is burnt downward instead of upward, and the common air is heated before it reaches the flame; as a gas flame consumes about fifteen times as much air as gas, care is taken to heat this air as much as possible before it comes into contact with the gas. The flame of the Wenham lamp has the form of a flat, horizontal ring, resembling a quoin in shape, but not so large when the lamp is of any ordinary size. The flame has no invisible or blue part to it, but over its whole area is intensely and equally luminous, and is more painful to the eyes than a gas flame to look at for any length of time, because of its brilliancy and its being richer in the rays of the blue end of the spectrum. There is little or no flickering with the flame, or variation in its form, but it is simply a steady, luminous ring.

The accompanying diagram, Fig. 1, represents the whole arrangement. In this cut A is the air inlet, and B the regenerator; the latter is somewhat massively made in iron, and takes up the heat from the gas-flame below to communicate it to the incoming air. A cylinder, C, conveys the heated air to the burner through perforated disks; D is the burner, E the flame, F the reflector, G the fastener of the ring, J, which carries the lamp-glass, K, and has a hinge at H. The chimney is at L, M is the gas supply pipe, and N the heat disperser.

It was necessary that the glass hemisphere, K K, should be light, and this was a difficulty, most of those

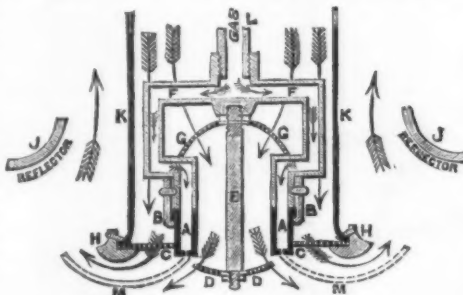


FIG. 2.

in the market being heavy, with a very thick glass rim at the top. Some of lighter form and better quality are made in Paris. The company so far has been using bowls of thin glass cut from the ends of flower shades, and fitted with an artificial rim invented and patented by Mr. Wenham; it consists of a band made of asbestos, cemented to the glass by silicate of soda.

A section of the burner is represented in Fig. 2. In this cut A is the porcelain burner, held in position by the ring, B. C is a perforated disk, and D a perforated button; E the stem supporting the button, F the gas way to the burner, G a perforated dome, H a ring secured by a bayonet lock, K the external cylinder, L the gas supply pipe, and M the flame. The gas issues in a horizontal curve from a ring of holes in the

burner. Mr. Wenham finds that to get the best light, the gas must issue in a series of streams rather than as a thin sheet; the air gets at it better. When the flame of this lamp is turned on so that little projections begin to appear at the outside edge of the ring of light, the arrangement is giving the maximum illumination.

The external appearance of the simplest form of the Wenham lamp is represented in Fig. 3, but it is, of course, made of various shapes and sizes, and with more or less attention to the requirements of the luxurious.

Mr. F. W. Hartley has photometrically tested the illuminating power of the flame of the lamp at 45 deg. from the vertical, and gives the following certificate of the results:

Lamps tested.	Gas burned per hour.	Total light obtained.	Light per cubic foot of gas.
	Cubic feet.	Candles.	Candles.
No. 1	6.4	55.00	8.60
" 2	12.0	122.50	9.50
" 3	15.2	171.00	11.40

Mr. Hartley remarks about the above figures that the vertical lighting power on the average of the tests was more than 50 per cent. greater than with angular lighting. The "total light" and "light per cubic foot" mean the light of standard sperm candles, and the figures gives the number of these which it would have been needful to burn at one time to produce a light equivalent to that of the Wenham lamp. The average amount of light yielded per cubic foot of gas burned from an average burner does not exceed, he says, the equivalent of 2.6 standard sperm candles.

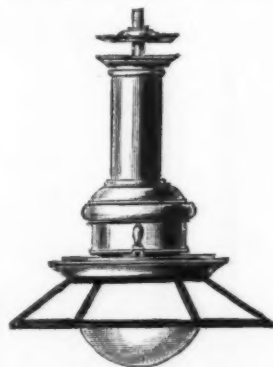


FIG. 3.

Dr. John Hopkinson, F.R.S., and Mr. George Livesey have also tested the flame of the lamp photometrically; their results, given below, agree closely with those of Mr. Hartley:

Lamp.	Feet per hour.	Total light.	Equivalent per cubic foot.
		Candles.	Candles.
No. 1	6.4	54.1	8.5
" 2	12.8	121.6	9.4
" 3	15.1	173.9	11.4

In these tests, taken at 45 deg. from the vertical, reflectors were used. The same referees report that "at Mr. Wenham's express desire the experiments were made with the lamps complete with their reflectors, just as they would be used, and the light was tested both at the vertical and angularly at 45 deg." The average light directly under the lamps at the same distance from the flame was about 55 per cent. more than at 45 deg.

Some photometric tests of the economy of the Wenham light made in comparison with an ordinary gas flame under the same conditions in each case—that is to say, both without reflectors—would be of scientific interest. At the same time, the Wenham light is of unusual brilliancy, as any visitor to the exhibition may see at a glance.

THE INFLUENCE OF MAGNETISM UPON THE CHARACTER OF THE SPECTRAL LINES.

By CH. FIEVEZ.

FARADAY'S discovery (1846) of the rotation of the plane of polarization of light under the influence of magnetic forces made manifest the relation existing between polarized light, magnetism, and electricity.

The action of magnetism upon the electric spark while passing through highly rarefied gases was plainly shown by the researches of De la Rive and by the spectroscopic experiments of Trève, Daniel, Secchi, and Capron.

According to De la Rive and Daniel, this phenomenon obeys the laws of electro-dynamics, and the results observed, the increased luminous power of the spark and of its spectrum, are due to a local condensation of the gaseous medium. Secchi, on the other hand, ascribes them to the diamagnetism of the gases, *i. e.*, to a repulsion which the magnet exerts upon the rarefied gases occasioning a strong diminution of the gaseous surface in the section of the tube traversed, and thereby an elevation of temperature.

According to these physicists, the influence of magnetism upon a spark traversing rarefied gases depends merely in a change of the resistance of the gases thus traversed. Cazin has also concluded from Secchi's experiments that "there is no spectrum peculiar to magnetism, *i. e.*, that the magnet exerts no direct action upon the rays emanating from the source of light."

This inference, however, goes beyond the known facts, for nothing forbids us, on the other hand, to ascribe the increased luminosity of the spark and its spectrum to the action of the magnetism upon the luminous rays themselves.

However this may be, the question may be answered more accurately, even if perhaps not as yet finally, and that by means of experiments where magnetic forces may act upon the movement of light and heat without anything intermediate save ponderable matter. Magnetic experiments with flames fulfill these conditions.

The influence exerted by magnetism upon the direction of flames has long been observed, and it is known that all flames display the same phenomena in different degrees. It has only to be decided whether the magnetic action is confined to a change in the direction of the gaseous masses, or whether it extends to the luminous undulations themselves.

Although spectral analysis might decide this question, it is necessary to combine the most favorable conditions of magnetic intensity and of the dispersion of light in order that the spectral modifications produced may not escape observation.

The spectroscopic appliances of the Brussels Observatory, including a very powerful dispersion apparatus and a Faraday's electro-magnet constructed by Ruhmkorff, which is excited by a current of 50 amperes, enabled the author to attempt the solution of this question.

The oxyhydrogen flame of a small blast was driven horizontally upon a piece of charcoal saturated with soda placed between the conical keepers of the electro-magnet, which were at ten millimeters distance from each other. An image of the flames was thrown by a double objective upon the slit of the spectroscope. The quantity of oxygen introduced into the flame permitted the temperature to be regulated in such a manner

direction of the magnetic axis undergoes the same changes under the influence of magnetism as that of a flame perpendicular to this axis.—*Acad. de Bruxelles* [3], vol. ix. (1885).

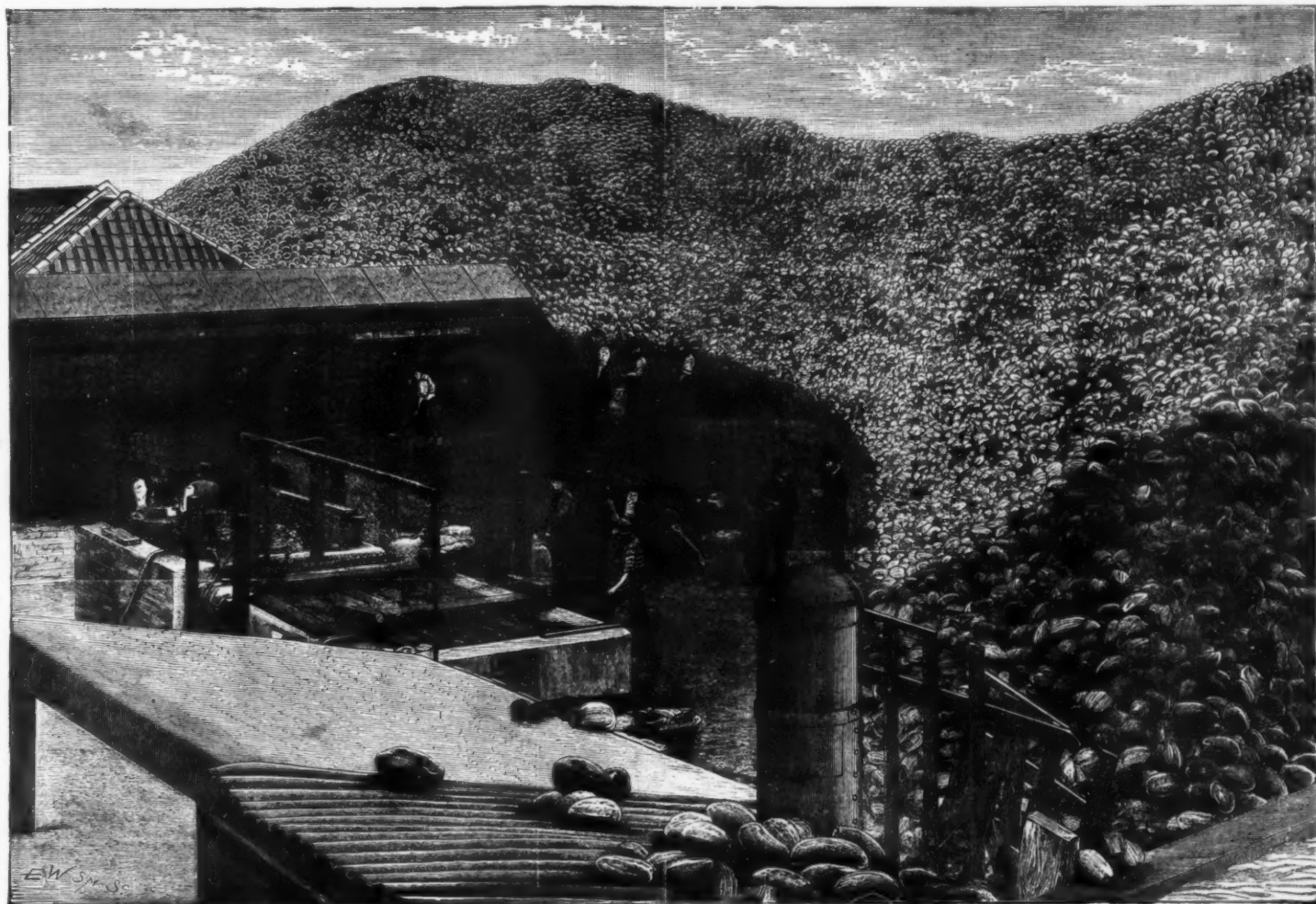
COCOA-NUT FIBER.

It was Linnaeus who first called the palms the "princes of the vegetable kingdom," but it has been reserved to writers of the present day to designate the cocoa-nut and the palmyra respectively the "prince of palms;" which of these two plants, however, is most entitled to the term it is difficult to say, for we read that the palmyra (*Borassus flabelliformis*) has been immortalized in a poem in the Tamil language, and though 801 uses of the palm have been thus recorded, the list is by no means exhausted. Whether it would be possible to enumerate so many uses for the cocoa-nut palm (*Cocos nucifera*) I have not been at the trouble to inquire, but I venture to believe that for sterling value as a commercial plant the cocoa-nut can compete any day with the palmyra, or any of its allies.

It would seem that with a plant so well known as this, and about which so much has been written, nothing now remains to be said. It is an old story to be told that the outer husk yields coir; that the inner hard shell can be, and is generally, carved into ornamental cups; that the kernel of the nut itself is edible when fresh, and that it yields large quantities of oil when dried. These are facts known to all who know a cocoa-nut when they see it, and what schoolboy is there who is not acquainted in some way with this

Islands; the quantity landed in the United Kingdom being about 12,000,000 yearly. Nearly all the nuts are imported in the husks or outer covering, from which, on arrival, they are stripped by men using two fine-pointed steel chisels, and who, by constant practice, became so skillful in the art that many are able to open 1,000 to 1,200 nuts per day. The nuts themselves after being removed from the husks are generally sold to wholesale fruit dealers, who, in turn, supply the retailers, costermongers and others, but they are likewise often sold under the hammer at public auction.

After removal from the husk they are sorted into seven sorts or varieties, known respectively as large milky, middle size, small, starters, milky growers, green, and dry. Those from Trinidad are the sweetest in flavor, and are mostly preferred by the manufacturing confectioners, biscuit-makers, and others, though the Ceylon nuts run them very close in quality. Cocoa-nuts are largely used in the North and West of England, and they are also in great demand at holiday times, at fairs, on racecourses, and such like gatherings in all parts of the kingdom. The husks, after the nuts have been cracked, are stacked in the yard in the open air, as shown in the engraving, until they are required for conversion into fibre; for this purpose they are first passed singly through a powerful "crusher," or "back-breaker," driven by steam power, with large revolving corrugated wheels, which flatten the husks, and, to a certain extent, make them more pliable; but after this severe pressure, so springy is the nature of the husk that, somewhat like a sponge, they immediately assume their original shape on emerging from the



COCOA-NUT FIBER MANUFACTORY.

that the spectral lines D_1 and D_2 could be made to appear at pleasure.

Under these conditions the sodium lines D_1 and D_2 , which prior to the passage of the magnetizing current were but narrow and not inverted, became immediately longer, broader, and more luminous as soon as the electro-magnet was set in action.

If the luminous lines D_1 and D_2 are already broad before the electro-magnet is brought into play, they become still broader, and are inverted (*i. e.*, there appears a black line in the center of the broad luminous band) during the transit of the magnetizing current.

If the bands are already expanded and inverted, the expansion both of the luminous band and of the black line increases considerably.

These phenomena, which immediately disappear on the interruption of the current, can also be observed, though with less intensity, in the red line of potassium or lithium, in the green line of thallium, etc., if a trace of these metals or of their salts is laid upon the charcoal.

If instead of the conical armatures of the electro-magnet we use flat ones, so that the entire length of the flame is between the armatures, the lines D_1 and D_2 , which are already extended and inverted, display a double inversion (*i. e.*, a shining line appears in the middle of the black line) when the electro-magnet is set in action.

These experiments, which demonstrate the influence of magnetism upon the luminous undulations without the intervention of the electric spark, show likewise that the phenomena which appear under the influence of magnetism are identical with those produced by an elevation of temperature.

The spectrum of a flame which coincides with the

familiar nut? But each one of its uses might be dilated upon, and to use an oft-repeated term, "volumes might be written" upon each; but our business at present is only with the husk, apparently a minor portion of the cocoa-nut, commercially considered. A glance at the engraving, however, will show that a large trade must be centered about these "unconsidered trifles," and that such is the case I shall endeavor to show by briefly recording what I saw on a visit to the cocoa-nut fiber works of Messrs. Chubb, Round & Co., situated in West Ferry Road, Millwall. This firm is one of, if not the largest importers and manufacturers of cocoa-nut fiber, and their stock of material, which is well shown in the engraving, is a very striking sight. The enormous heap of husks, which, indeed, is known in the locality as the "mountain," comes upon view immediately upon entering the premises, and one can scarcely, at first sight, realize the fact that the enormous pile is composed entirely of these apparently useless portions of the fruit. At the time of my visit this reserve stock of husks was estimated at considerably over a million and a half, and presented an appearance as shown in the engraving, which is from a photograph taken by Mr. John G. Horsey only a week or so previously. Before proceeding to describe the various processes through which the husks pass to convert them into marketable material, it will be well to say something about the nuts themselves.

Cocoa-nuts, or, as they are generally termed in the trade, coker-nuts, to distinguish them from the Theobroma cacao, which furnishes cocoa and chocolate, are shipped principally from Trinidad, Jamaica, Demerara, Tobago, several of the other Leeward Islands in the British West Indies, Ceylon, Belize (British Honduras), all round the coast of America, and the Fiji

crusher. They are then thrown into huge stone tanks, each holding many thousands, where they undergo several hours' steaming and soaking. Great care and skill are required to know how long to keep them in the tanks, husks from different countries requiring more or less time, according to circumstances, such as age, thickness of outer cuticle, substance of fiber, and other peculiarities known to the manufacturers. In the tanks the husks swell considerably, and have to be kept down by heavy pressure. One of the tanks filled with husks is shown in the center of the engraving.

After the husks are sufficiently soaked they are ready for the mills, which are technically known as "teasers" or "devils," and consist of cylinders or drums, each being studded on the outer circumference with about 3,000 fine or thick 3 inch steel teeth, specially tempered. The mills vary slightly, according to certain requirements. They are driven by steam, and revolve with great rapidity, requiring the utmost care and constant attention of the workmen. Each husk is divided longitudinally into thin pieces, and each piece is passed into the mill separately by the workman between two steel rollers, the workman retaining a firm grip of it so as not to allow it to pass out of his hands; but the few moments he holds it there the drum with its numerous steel teeth is revolving, and combing out the irregular fiber and refuse. After one-half of the slice of husk is thus cleaned the workman reverses it, passing in the other half. The continual feeding of these mills gives such strength of wrist and dexterity to the workmen that what appears a very dangerous operation is gone through with wonderful rapidity, and each slice of husk is passed through three of these mills in succession, occupying but a few seconds from the time that the crude husk is passed into the mill

until it comes out a perfectly cleaned bundle of light brown separated fibers; these bundles are next laid out in drying rooms on heated iron tables, to perfectly dry them, when they are ready for making brushes and brooms of various kinds.

But to return to the mills. It will be seen that the principal attention has been given to the long clean fibers used for brush making, but there are other products to which I have not yet alluded. If a cocoa-nut husk is cut through transversely, it will be found that immediately under the outer woody coating the long brush fibers, if we may so call them, are deposited to the thickness of about half an inch; nearer the center, and immediately surrounding the nut, the fibers are more irregular, somewhat matted, and mixed with soft brown refuse. In the process of passing through the mill and separating the brush fiber, this finer fiber and refuse is thrown out at the back, from whence it is collected and placed on elevators, and carried automatically into the mouths of double rotary screens, or "willows," peculiarly made for the purpose, a spindle fitted with arms or rods running the entire length; and after many revolutions and much tossing about the fiber is separated, and falls out at the lower ends clean and ready to be dried. This fiber is used for matting, and is not only supplied by the firm in large quantities for mat makers, but also to the government for mat making in prisons; it is further largely used for stuffing mattresses, saddles, etc. The refuse, by a special process of the present proprietor, is separated into two different qualities, the ordinary coarse kind being used for general horticultural purposes and the granulated for conservatory use and potting.

Enormous quantities of this cocoa-nut fiber refuse are produced by the firm. A heap is shown behind the tank in the engraving, and I was informed that it was no uncommon thing for them to dispatch 20 tons in one consignment, and that the material is sent to all parts of the world, including America, Africa, Australia, Sweden, Germany, France, Holland, etc.—the latter countries using it extensively for bulb growing. It is not a little remarkable that this refuse cocoa-nut fiber should in some cases find its way back, in a changed form, to the countries from whence the nuts were originally brought.

In conclusion, I have to acknowledge my indebtedness to Mr. Thomas Nevell, the present proprietor, for his kindness in allowing me to inspect the works, for his courtesy in personally showing me over them, and carefully explaining the details of manufacture, as well as for much of the information contained in this paper. —John R. Jackson, Royal Gardens, Kew, the Gardeners' Chronicle.

THE JAPANESE PERSIMMON.

THE resources that we possess in food and alimentary products are so abundant and varied that we are somewhat indifferent when it becomes a question of increasing the quota. Nowhere are markets better stocked than in France, especially with fruits and vegetables; and these have no formidable rivals either as regards number or quantity, as even foreigners confess. This is one of the reasons that explains our extensive exportation of products of this nature to the different countries of Europe. When we borrow foreign cultures, they remain in most cases in an experimental state, and it takes a long time or exceptional circumstances to bring them into daily consumption.

For several years past the horticultural journals have been telling their readers about a fruit which is new to Europe, which ripens in our latitude, and which is nevertheless ignored by most of us. It is in China, and especially in Japan, that the kaki is cultivated on a large scale. It is a national fruit, and one that is the

name derived from one of them, *Diospyrus ebenum*, a species that furnishes the Indian ebony-wood. The heart of the wood, or duramen, is permeated with a brown matter that gives the black color which is so well known, while the sap-wood, being whitish, is carefully separated in order to reduce the expense of carriage when the ebony is shipped to Europe.

The fruits of several species of *Diospyros* are edible, while, on the contrary, those of others are not. The quantity of tannin that these plants contain is large, and the green fruits, and even the ripe ones of several of them, are insupportable, notwithstanding their flattering appearance.

Two of the species which endure our climate well, and which are trees of quite beautiful form, *D. lotus*, of Italy, and *D. virginiana*, of North America, are of this number. Moreover, the fruit of the kakis are not

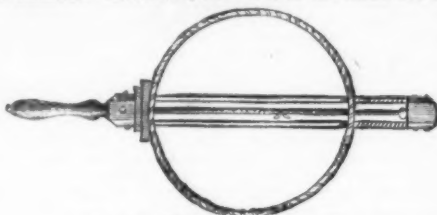


FIG. 1.—THE RING GAME.

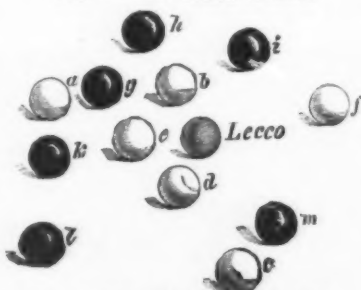


FIG. 2.—THE GAME OF BOCCIA.

utilizable before complete maturity; they must be mellow and fully ripe, that is to say, the tannin that they contain must have undergone some modification during maturation in order that they shall be savory. Then their flesh somewhat resembles in taste a mixture of plum and apricot.

The varieties of kakis have been classified as the sugary and bitter. The former ripen at the end of summer, while the latter take quite a long while to reach the necessary degree of maturity, and are then named winter kakis. It is from these that preserves, in a sort of prunes, are made, which are put into casks or are dried previous to shipment.

The form and size of these fruits are variable. Some are of the size and shape of a plum, some are elongated, and others are more or less spherical and attain the dimensions of a peach, with the yellow color of the apricot.

The culture of the kaki is an accomplished fact in certain regions of North America, especially in California. Accurate data prove that half a dozen varieties have been making their appearance, for several years past, upon the tables of San Francisco, under the name of Japanese persimmons.

These trees are not cultivated for their fruit alone. Their habit is said to be very beautiful. Their wood, which is very close grained, is highly esteemed in Japan, where it replaces our walnut. It is veined with black, and furniture made of it has a very peculiar appearance. Finally, while the fruit is green, the juice expressed from it serves for staining wood and fixing the whitewash of Japanese houses.—*La Nature*.

TWO GAMES.

Tossing the Ring.—This game consists in throwing a ring (Fig. 1) into the air and preventing it from dropping, by catching it again during its flight. When the players are of equal number, they strive to see who shall throw his ring to the greatest height and catch it oftenest.

A variant of this game consists in throwing and receiving the ring by means of quite a simple apparatus, such as is shown in the cut. This game is much played in Germany.

The Game of Bocchia.—This game, which is an Italian one, is played with thirteen balls, six of them white, six dark, and one red, called *lecco* (goal). This supposes the number of players to be from two to twelve. When a larger number of persons play, it requires a corresponding number of additional balls. The *lecco* is the movable goal, and is thrown by the person chosen by lot. Each side endeavors to get its balls as near as possible to the goal. The balls that are nearest the latter count so many points and win the inning.

Being given the position of the balls shown in Fig. 2, the balls *b e d* are nearest the goal, and the side which is playing with white balls has gained three points. The balls *a c f* do not count, since *g* and *i* are nearer the goal. Notwithstanding this, the balls *g* and *i* count nothing for the side playing with black ones.—*Science et Nature*.

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THE JAPANESE PERSIMMON.

object of every care on the part of the inhabitants. The number of varieties of the kaki (*Diospyros kaki* of botanists) is large. Mr. Dupont, an engineer of the navy, who has given some valuable notes on Japan, where he lived for several years, mentions thirty-three varieties that are known to him, with names which we shall spare our readers, since from the Sakourakaki, in passing through the Tsouroumarou, the Kochioumarou, the Kizawachi, and the Gochonkaki, we have still 25 names of varieties which are too far removed from our orthography to allow us to dwell further upon them.

The *Diospyri* belong to the order of Ebenaceae—a

In France we can hope to cultivate these fruit trees only in our southern regions. Yet a Chinese species called *tsiche*, that Carriere has named *D. costata*, seems more hardy than the others, and is capable, when trained against a wall, of ripening its fruit in the latitude of Paris; but this must be considered a fortunate exception in our favor.

As with our own fruit trees, it is indispensable to graft the Japanese persimmons in order to preserve the races that are obtained. The Japanese always have recourse to this. Here, we must select the *D. lotus* as a stock, or, better yet, *D. virginiana*, which does very well.

